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ORIGINAL ARTICLES

Electromyographic Analysis of the Physiologic Components of Tremor. Margaret H. Clare, R.P.T.T., and George H. Bishop, Ph.D. 559
Discussed by Drs. Charles Wise and Leonard Yamshon.

The Oscillographic Recording and Quantitative Definition of Functional Disabilities of Human Locomotion. R. Plato Schwartz, M.D., and Arthur L. Heath B.S. 568

The Influence of Mecholyl and Histamine Ion Transfer on Recovery from Fatigue. F. A. Hellebrandt, M.D.; Ellen Neall Duvall, Ph.D.; Sara Jane Houtz, B.S.; Annie M. Parrish, B.S., and Helen V. Skowlund, M.S. 578

Thermal Gradients in Man. Comparison of Temperatures in the Femoral Artery and Femoral Vein with Rectal Temperatures. Ludwig W. Eichna, M.D. With the technical assistance of William H. Becker 584
Discussed by Drs. Steven M. Horvath, Julia F. Herrick and Eichna.

Progress Report 593

Editorials 595

Correspondence 599

Medical News 602

Book Reviews 605

Physical Medicine Abstracts 609

EDITOR OF THE MONTH

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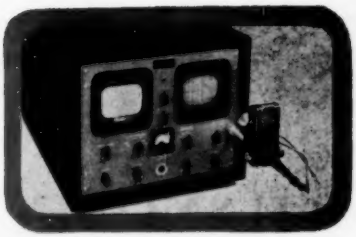

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ELECTROMYOGRAPHIC ANALYSIS OF THE PHYSIOLOGIC COMPONENTS OF TREMOR *

MARGARET H. CLARE, R.P.T.T.

Research Associate in Physical Medicine and Neurophysiology,

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and

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ST. LOUIS

In comparing electromyographic records from normal and from pathologic subjects it becomes evident that the pathologic state exhibits essentially an exaggeration of basic phenomena found in varying degrees in the normal states. Further, there is a wide range of variation within the limits of the "normal," if normal is defined as a condition in which no serious embarrassment of function is present in common forms of activity.

Tremors most commonly found can be divided into two groups: those in which opposing muscles contract in alternate bursts, of which parkinsonian tremor is the classic example, and those in which the bursts are synchronous in opposing muscles. The latter type, commonly found under conditions of nervous tension, is the chief subject of this report. These two tremors appear overtly as "coarse" and "fine," respectively, although various complications of pattern, frequency and intensity confuse this correlation. All normal subjects can induce an alternating, or clonic, tremor of the arm by clenching arm and shoulder muscles and voluntarily initiating a reciprocating movement.[1] Many normal subjects can induce a synchronous tremor, particularly in forearm muscles, by simple clenching without voluntary movement.

The phenomena of tremor can be broken down into a number of physiologic factors, or components, of which the chief ones are periodic action and inaction in a given muscle, involving mutual facilitation of motor units; reciprocal innervation of opposing muscles, presumably at both spinal and higher levels, and spread of excitation to adjacent or even to opposing centers for muscle activation. Predominance of reciprocal action characterizes alternating tremor; predominance of spread of excitation characterizes synchronous tremor. These factors can be detected in the activity pattern of many normal subjects, who show varying degrees of tendency toward tremor, especially under nervous tension, excitement or fatigue or during considerable effort. Tremors tend to manifest themselves at the start and particularly during the relaxation of effort, especially if relaxation is carried out gradually.

Preliminary to setting up criteria for diagnosing or even studying pathologic tremor, it seems desirable to study in detail the pattern of tremor and its variations that can be induced in normal subjects. In fact, a tremor which is established deliberately in a normal subject often becomes uncontrollable under conditions which can be experimentally maintained. Such tremors are quite similar to those of pathologic subjects, in whom there are such disturbances of normal pattern that function is impaired. In such cases tremor may become the dominant

* Read at the Twenty-Sixth Annual Session of the American Congress of Physical Medicine, Washington, D. C., Sept. 9, 1948.

* Aided by a grant from the Rockefeller Foundation and the Baruch Committee on Physical Medicine.

1. Bishop, G. H.; Clare, M. H., and Price, J. P.: Patterns of Tremor in Normal and Pathological Conditions, J. Applied Physiol. 1:122, 1948.

feature, present during rest as well as during activity. In other cases there may be constant tension in antagonistic muscles, which is in effect rigidity, and tremor appears to be the periodic counterpart of this rigidity.

Methods and Materials

In this study, electromyograms have been recorded chiefly by means of a 3-channel ink-writing oscillograph (Grass) coupled with 5-stage amplifiers. Some have been made on an 8-channel Offner oscillograph. For more detailed and accurate recordings, camera strips on sensitized paper were made of the activity as shown on a cathode ray oscilloscope.

Surface leads made of a wet mixture of powdered modeling clay and plaster of paris have been used. Various combinations of muscles have been recorded to study the patterns of activity, especially protagonists and antagonists working around a given joint. The combinations used most frequently have been the biceps brachii, brachioradialis and triceps of one extremity; the flexors and extensors of the wrist and fingers and, in the lower extremity, rectus femoris, tibialis anterior and gastrocnemius or peroneus longus.

The normal subjects used were laboratory and office personnel, students and staff physicians. Patients were drawn from various sources.

Results

Periodicity of Response.— Normal subjects exhibit numerous variations in pattern of muscle activity simulating the patterns of pathologic conditions but below the level of overt impairment of function. When recorded from surface leads, the "normal" pattern is a tetanus consisting of spikes of variable amplitude without demonstrable periodicity; the amplitude and frequency of spikes increase with increased effort; there is clean reciprocal inhibition of antagonists. However, even in normal subjects there is increasing activity in antagonists with increased activity in protagonists, perhaps involving stretch reflexes, a mechanism employed to protect not only muscle structures but also the joints. This overflow to antagonists also is affected by posture and by emotional tension or nervousness.

Chart 1. — Spiking during rest and weak contraction, in pathologic and normal subjects. *A* and *B* are records from patient H. D. (with postencephalatic Parkinson's disease) at rest. *B* is the same as *A* with greater amplification. *C* is a record from subject M. C. (normal), showing weak dorsiflexion, gradually increasing strength slightly. *D*, *E* and *F* are records from subject H. T. (normal). *D* shows activity when the subject thought she was relaxed. *E* shows rest and beginning of weak dorsiflexion, *F* is weak flexion of the elbow, slightly decreasing and then increasing strength of contraction. Abbreviations used for muscles are: *Bi* = biceps brachii; *Tri* = triceps; *Brach.* = brachioradialis; *Rect.* = rectus femoris; *Tib.* = tibialis anterior; *Gastroc.* = gastrocnemius. All calibration marks indicate 50 microvolts.

There appears a tendency in some normal subjects to synchronize motor units into discrete spikes during incomplete relaxation or weak contraction, result-

ing in periodic activity of a sort (chart 1). Such spikes increase in frequency with increased effort, as if the frequency were that of the essential motor unit discharge, and pass over into a normal tetanus with sufficient effort. This phenomenon does not appear to involve tremor, from which it differs in its variable frequency and in marked synchronization to a series of single spikes as contrasted to a train of tremor bursts each usually showing several spikes. Many pathologic subjects during apparent relaxation or in certain postures show such a simple residual tonic spike sequence without obvious tremor. This is not primarily an index of pathologic change, although it is perhaps more frequently found in subjects in whom motor activity is otherwise impaired than in normal subjects.

As previously stated, persons without detectable pathology can volitionally induce tremor, and under certain situations may show involuntary tremor. It is common experience that fatigue, prolonged stress, either physical or emotional,

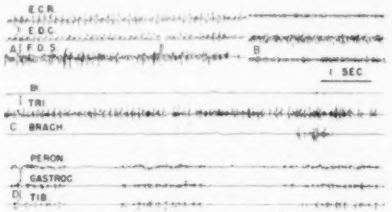

Chart 2. — Periodicity in normal subjects accentuated by fatigue and emotional stress. *A* and *B* are records from normal subject M. C., holding a pencil, with slight tension on finger flexors. *A* was taken twenty-four hours after a tennis game, while muscles still felt "tired and sore." *B* was taken at a later date, when the arm did not feel tired. *C* is a resting record from subject J. S., a student, shortly after a final examination in one course. *D* is a record from subject G. B., a staff physician, after an argument; it shows periodic activity synchronous in all three muscles during a repeated weak dorsiflexion of the ankle followed by relaxation. Abbreviations used for muscles are: *E.C.R.* = extensor carpi radialis; *E.D.C.* = extensor digitorum communis; *F.D.S.* = flexor digitorum sublimis; *Bi.* = biceps brachi; *Tri.* = triceps; *Brach.* = brachioradialis; *Peron.* = peroneus longus; *Gastroc.* = gastrocnemius; *Tib.* = tibialis anterior. All calibration marks indicate 50 microvolts except the last line of D, which is 500 microvolts.

and certain drugs induce or accentuate tremor. For instance, an involuntary tremor appeared at irregular intervals, during rest or with minimal contraction of muscles, in a normal subject, a student, recorded shortly after a final examination in one course (chart 2). In another subject, twenty-four hours after a tennis game, when the arm felt fatigued and uncomfortable, such a tremor appeared.

Prolonged effort also acts to accentuate periodic activity. In normal subjects, as in the abnormal, this periodicity may appear during weak contractions, whereas it tends to be obscured by slightly increased effort, and may reappear with very strong effort. These tremors may run as high as 14 to 16 per second, a rate too fast for the mass of the arm to follow in gross movement; hence there is not the periodic passive stretch involved in clonic activity (Lloyd).[2] Such fast tremors, typically synchronous in antagonistic muscles, do not build up in amplitude as the contraction continues, as is often observed in parkinsonian tremor, in which gross movement is adequate to set up reciprocal stretch stimuli reinforcing the initial periodicity. On the other hand, clonic or parkinsonian type

2. Lloyd, D. P. C.: Principles of Spinal Reflex Activity, in Fulton, J. F.: Howell's Textbook of Physiology, Philadelphia, W. B. Saunders Co., 1946, p. 153.

tremors (which may be either alternating or synchronous) rarely show a frequency above 10 per second. If antagonists are involved synchronously at a higher frequency, no visible tremor movement may result, although the subject may be aware of tremorous impulses, which appear in the record as regularly periodic pulses. During such records under constant effort the periodicity may be manifest only occasionally or be obscured to varying degrees by more random tetanus.

Spread of Excitation to Antagonists. — Tremor appears on a background of contraction; it may be looked upon, in fact, as contraction, voluntary or involuntary, which is periodically inhibited or suppressed. Synchronous tremor in antagonists, then, has a background of simultaneous contraction of opposing muscles. Such contraction may occur without tremor and in the normal subject may be interpreted as a holding reaction — for instance, to guard against overextension at a joint. Its extreme manifestation constitutes a clenching of the muscles without overt movement. The point in noting it here is that it opposes reciprocal innervation of an antagonist and constitutes a reversal of the normal reciprocal inhibition. It appears to occur as a spread of the excitation designed to activate one set of muscles only and to involve hyperexcitability at the cord level when prominent. When the contraction of the protagonist is periodic, this periodicity also tends to spread synchronously to the antagonist.

Such overflow of excitation can be observed in various situations (chart 3): 1. Muscles not required in a movement may be involved in tetanus when the contraction of the volitionally activated muscles becomes strong. 2. Synchronization of details of pattern may occur in several muscles. 3. Doubling of tremor rate in initially alternating parkinsonian type tremor may occur by each of two opposing muscles taking on the alternate rhythm of its antagonist as well as its own. This results in a pattern similar to the synchronous tremor of nervous tension, but usually showing evidence of two sequences of bursts alternating. 4. Tension may appear in a volitionally relaxed arm when the opposite arm is voluntarily clenched. These phenomena are presumably related to physiologic "reinforcement," in which voluntary activation of one set of muscles may increase the effect of a reflex stimulus to another unrelated muscle.

When the activity of the primarily contracted muscle is periodic, simultaneous periodicity tends to occur in muscles to which the excitation spreads. Since voluntary clenching of muscles of a joint involves simultaneous activation of antagonists and since effort tends to induce synchronization of motor units and periodic activity in general, a "clench" tremor is an obvious expectation, even in normal subjects. Nervous tension and anxiety appear to accentuate both involuntary contraction of antagonists and periodicity of action. The resultant nervous tremor therefore seems to consist of the same components as the clench tremor of normal subjects and typically shows the same pattern (chart 4).

In normal subjects, when one arm is relaxed and the opposite clenched, there may be an overflow of activity to the "relaxed" side. The arm from which the recordings are taken is allowed to hang loosely at the side, so that no tension will be placed on it by bracing against a table or other object. This arm shows no activity at rest before the opposite arm is clenched. Then, as the clenching starts, after a brief interval of inactivity in some cases the muscle tension builds up in the "relaxed" arm, increasing as the contralateral tension is increased. This involuntary activity cannot be terminated as long as the opposite arm is tense, but it stops as soon as the opposite arm is relaxed. It is also interesting to note the pattern appearing when a slight tension is maintained in the flexors of the arm recorded and the opposite arm is clenched. The recorded triceps shows no activity either before or after the contralateral arm is clenched — that is, during the time the recorded flexors are in mild contraction. However, while the opposite

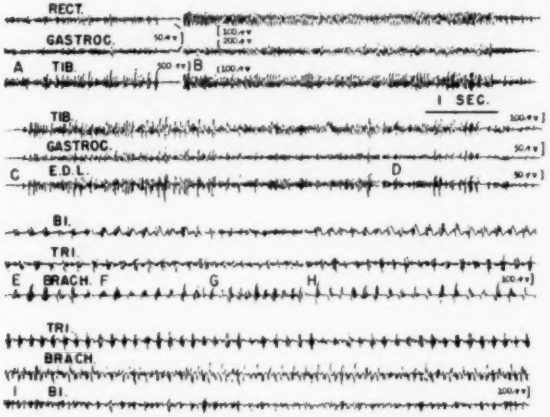

Chart 3. — Spread of excitation in normal and pathologic subjects. *A*, *B*, *C* and *D* are records from normal subject L.L., during dorsiflexion of the ankle, showing synchonous patterns of activity in two or three muscles simultaneously. *A* is weak effort; *B* is strong effort; *C* and *D* are weak dorsiflexion. *E*, *F*, *G* and *H* show doubling of tremor rate in volitionally induced tremor of normal subject M.C. Small bursts of activity synchronous with the activity of the flexors appear between regular bursts of the triceps. *I* shows doubling of tremor rate in involuntary tremor of Parkinson's disease in subject A.P.; rate in triceps is 6 to 7 per second and in flexors 12 to 14 per second. Abbreviations for muscles are: *Rect.* = rectus femoris; *Gastroc.* = gastrocnemius; *Tib.* = tibialis anterior; *E.D.L.* = extensor digitorum longus. *Tri.* = triceps; *Brach.* = brachioradialis; *Bi.* = biceps. Calibration as marked.

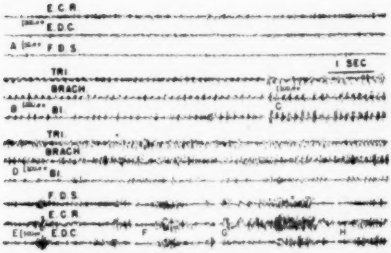

Chart 4. — "Nervous" and clench tremors. *A*, *B*, *C* and *D* are recordings from subject E.G., who has a "nervous tremor." *A* shows finger extension, with irregular tremor on a background of tetanus, considerable synchronization of patterns of three muscles. *B* is a volitionally induced tremor. *C* is the same, during an attempt to increase the rate. *D* is an involuntary tremor, sometimes synchronous, sometimes alternate, induced by clenching the arm and shoulder. *E*, *F*, *G* and *H* are recordings from subject R.B.K., a neurosurgeon, during an animal operation (using rongeur). These show irregular synchronous tremor in all three muscles, especially at the beginning or end of a movement. Abbreviations for muscles are: *E.C.R.* = extensor carpi radialis; *E.D.C.* = extensor digitorum communis; *F.D.S.* = flexor digitorum sublimis; *Tri.* = triceps; *Brach.* = brachioradialis; *Bi.* = biceps. Calibration as marked.

arm is clenched, the activity recorded from the flexors increases in amplitude and the triceps also shows moderate activity. This clenching in the arm which volitionally is only maintaining slight flexion, appears to be an overflow phenomenon of the type under consideration.

In certain normal subjects, as well as in some pathologic subjects, a sudden spiking tetanus may occur in a muscle not used in a given movement, as effort is increased. For example, when the quadriceps is being used to extend the knee, the tibialis anterior may suddenly show considerable activity if a strong

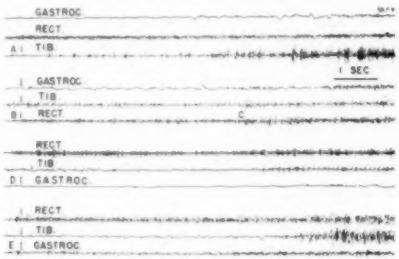

Chart. 5. — Activation of the tibialis anterior during extension of the knee. Recordings show weak extension, with slightly increasing effort, by normal subjects. *A*, subject L.L.; *B* and *C*, subject R.A.K. (*C* is same as *B* with increased strength); *D*, subject M.C.; *E*, subject H.T. Abbreviations used for muscles are: *Gastroc.* = gastrocnemius; *Rect.* = rectus femoris; *Tib.* = tibialis anterior. All calibration marks indicate 50 microvolts except the last line of *B* and *C*, each of which indicates 200 microvolts.

effort is made (chart 5), even though the foot is not braced against any surface and there is no conceivable way in which the latter muscle can assist in this action of extending the knee. It is possible that the stretch reflex may be involved in this activity, but since the leg can be supported with the foot hanging, unsupported, in the same position, without inducing activity in the tibialis anterior, this does not appear to be the probable explanation. This, again, seems to be an overflow from the internuncial pool which supplies the motor neurons of the quadriceps, to activate also the tibialis anterior through facilitation produced by increased effort. The same picture is often seen in patients with weakness or paralysis due to peripheral nerve lesions, poliomyelitis or other pathologic conditions.

Another evidence of overflow in the spinal cord is the highly synchronized pattern of activity simultaneous in several different muscles innervated by different peripheral nerves — e.g., the rectus femoris, tibialis anterior and gastrocnemius (chart 6). Persons who show this pattern usually also show a spiky tetanus in general which indicates synchronization of activity of many motor units within one muscle as contrasted to the many smaller potentials of asynchronous activity.

In the standing normal subject, raising the heels, activating primarily the gastrocnemius and peroneus longus, may also induce lesser activity in the tibialis anterior. This opposing tetanus is accentuated in certain pathologic conditions, and the reverse action, contraction of the gastrocnemius and peroneus longus, while raising the toes may occur. Spread of excitation to antagonists appears to predominate readily over reciprocal inhibition in this set of muscles, a situation which is perhaps appropriate to the requirement of constant adjustment about a mean state in standing. This tendency is also manifest in pathologic

states resulting in ankle clonus. Stretch of the plantar flexors, then, often results in simultaneous bursts in the tibialis and gastrocnemius, instead of the alternate bursts that might be expected to follow stretch reflexes in the tibialis when the gastrocnemius contracts.

Comment

The neural mechanisms of reciprocal innervation and of spread of excitation can only be inferred at present. Lloyd points out that "each reflex has an in-

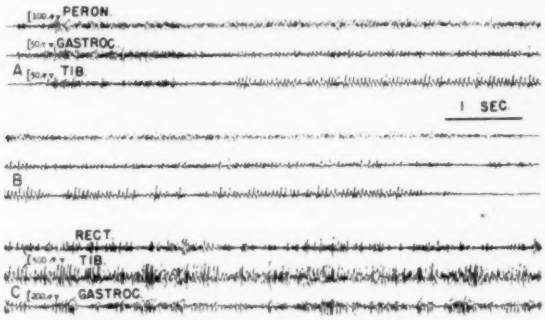

Chart 6. — Synchronous patterns of activity in all three muscles. *A* is a record of plantar flexon of the ankle by a normal subject A.K., showing a prolonged spike sequence most clearly in the tibialis anterior but also present in the other two muscles and synchronous in all three. *B* is a continuation of *A*. *C* is a record of normal subject B.S., standing on her heels. Abbreviations used for muscles are: *Peron.* = peroneus longus; *Gastroc.* = gastrocnemius; *Tib.* = tibialis anterior; *Rect.* = rectus femoris. Calibration as marked.

hibitory field as well as an excitatory field . . . . Stretch of a flexor muscle . . . was found to have an inhibitory effect on the opposing extensor muscle, this action being the inhibitory component of the stretch reflex in the flexor muscle itself. The inhibitory field of a reflex commonly embraces the moto-neurones of muscles whose action is directly antagonistic to that of the excited muscles."[3] A similar but opposing field may be conceived as overlying this, usually less available to the reflex stimulus but capable of overpowering the inhibitory influence. Conditions have been noted under which this reversal takes place in normal or impaired subjects. In pathologic cases one may infer a shift in emphasis between two normal mechanisms, rather than an abnormal element of action.

Similarly, tremor may be considered as due to an abnormal combination of normal factors, the most obvious factor being the grouping of activity into periodic bursts. In both normal and impaired subjects the combination of factors potentially resulting in tremor may occur with varying degrees of specificity and intensity, above or below the level of overt tremorous movement. The conditions included under the terms "nervous tension" or anxiety tend to accentuate this pattern. While such conditions tend to induce the fast synchronous tremor of opposing muscles, slower alternating or clonic tremors may occur, presumably depending on the constitutional makeup of the individual as much as they do upon any one specific inciting cause.

The tremor of nervous tension is typically not dependent on organic change; but whether or not there is organic cause, it appears to represent a type of hyperexcitability overpowering reciprocal inhibition and accentuating synchronization

3. Lloyd,[3] p. 162.

of many muscle elements, as if involving mutual facilitation. Such reversal of inhibition and increase of facilitation may be evident without tremor; the periodicity involved may be too high in frequency or insufficient in intensity to result in overt tremor; and the same factors operative in involuntary tremor can be induced in normal subjects.

In these circumstances it is precarious to take the muscle record alone as diagnostic of any specific pathologic change or of functional state, especially when fast synchronous tremor is involved. Rather, it is necessary to consider the pattern of activity in general of whole muscle groups, the effects of posture, state of interest or of relaxation of the subject under the conditions of the test, his subjective reactions as well as the intensity or character of the fine structure of the tremor and the effect on the pattern of muscle activity of experimental testing procedures. Even when such criteria are employed, it is probably impossible to distinguish by the muscle record alone whether a given tremor is of functional or organic origin and difficult to gauge even the degree of overall abnormality of function or to predict the degree of motor impairment.

Summary

There are circuits in the nervous system whose activations in normal or pathologic motor behavior can be detected as physiologic components of the behavior pattern.

The action of the mechanism of reciprocal innervation of antagonists is balanced in various degrees against an action of spread of excitation to muscles other than those primarily activated, including antagonists.

A process which can be loosely designated as mutual facilitation tends toward synchronization of muscle units into spike discharges. This synchronization is opposed by random activation from sense organs or other nervous pathways.

A "clonic" process which tends to break up continuous activation into alternate pulses of intense activity and periods of suppression of activity, presumably characteristic of the spinal level of function, is opposed by an action of higher centers smoothing such bursts to continuous activity. This list could be extended.

Abnormal motor behavior of either organic or functional origin usually can be interpreted as a disturbance of that balance of forces which constitutes the only definition possible of "normal" behavior and which is that balance or interaction of components resulting in reasonably effective motor activity. Usually no new components are required to explain the abnormal pattern.

One of the most striking deviations from normal pattern consists of tremor, of which two varieties are considered: the alternate clonic tremor of the type familiar in Parkinson's disease and the faster tremor usually synchronous in opposing muscles and found in states of nervous tension or anxiety. Both types can be readily induced in normal subjects.

In the normal or the pathologic subject, the analysis into components whose interaction determines the behavior pattern cannot usually be made from inspection of a casually recorded muscle pattern alone. It requires that the subject be put under test conditions which more or less critically reveal the activity of specific components of pattern. These components can be accentuated by various experimental conditions: test movements, posture, treatment with certain drugs, fatigue and even volitional movements.

Discussion of Papers of Drs. Leonard J. Yamshon and William Bierman * Miss Margaret Clare and Dr. George H. Bishop.

Dr. Charles Wise (Washington, D. C.): These two excellent papers clearly illustrate the growing usefulness of electromyography in basic physiologic studies. It is encouraging to see that such studies are becoming more and more closely affiliated with the field of physical medicine. Both papers deal largely with patterns of gross motion in the normal person. It is obvious that future observations on abnormal muscle patterns can be considered valid only when studied in relation to the preliminary findings of these two papers.

Dr. Yamshon's observations concerning deltoid function seem to be essentially in accord with the previous concepts regarding the action of this muscle. I should like to ask Dr. Yamshon a question, however, concerning the treatment of deltoid paralysis, even when the patient is supine but when the shoulder is in 90 degrees abduction. What is considered the position of physiologic rest for the deltoid? Even when the arm is held at the side, there is no electric evidence of deltoid activity; hence I should like to ask Dr. Yamshon whether he feels that prolonged abduction in deltoid paralysis, particularly when the patient is supine, is physiologically sound or necessary. I should also like to point out the usefulness of records such as those that Dr. Yamshon has obtained as teaching aids in kinesiology; it is to be hoped that in the near future electromyography will be used in teaching kinesiology to medical students and physical therapists.

The excellent paper read by Miss Clare brings to mind previous studies by Schwab and Brazier and others concerning tremors studied electromyographically in battle casualties during the recent war. These authors observed that tremors of function origin — that is, hysteria — or neuropsychologic origin consists primarily of synchronous contractions of both agonist and antagonist. Tremor associated with organic involvement of the central nervous system is essentially alternating in character, consisting of reciprocal contractions of protagonist and antagonist. Miss Clare has clearly pointed out that the mechanism of reciprocal innervation balanced in varying degree against the action of spread of excitation to muscles other than those primarily activated can explain the findings, both functional and organic. I believe that this is an important contribution. Is this tremor primarily a peripheral phenomenon, or are the higher centers primarily involved?

Dr. Yamshon (closing): Unfortunately, I am not in a position to answer the first question raised by Dr. Wise concerning the position of rest for the deltoid.

I should like to state that I am quite certain that electric spread did not influence the electromyographic pictures that we obtained. In our observations on muscles in the immediate vicinity of the electrodes on the deltoid we did not obtain microvoltages of sufficient magnitude to influence the definite patterns obtained from the deltoid when the particular motion was accomplished.

* The paper by Drs. Yamshon and Bierman, "Kinesiologic Electromyography. III. The Deltoid" appeared in the May 1949 issue of the ARCHIVES.

THE OSCILLOGRAPHIC RECORDING AND QUANTITATIVE DEFINITION OF FUNCTIONAL DISABILITIES OF HUMAN LOCOMOTION *

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and

ARTHUR L. HEATH, B.S.

ROCHESTER, N. Y.

In June, 1946 we presented a quantitative definition of normal human locomotion based on measurement of oscillographic records.[1] Summation curves of normal gait were also compared with those of simulated limps to illustrate the method of recording dysfunction.

Such summation curves are most useful in quantitating the function of the foot as a unit. But they do not reveal differences in the duration and magnitude of forces exerted through various levels of the foot. For such comparisons, data derived from the records are combined in other ways.

Since the force acting on any point is constantly varying in magnitude, comparisons are obtained through reduction to the average pressure value. This is obtained for each of the six recorded areas by totalizing the pressure values at successive 0.05 second intervals during the stance phase of each step and dividing by the number of readings made. The average value obtained permits direct comparison of forces irrespective of the time factor. To complete the analysis of a record, average pressure values are multiplied by the corresponding durations in seconds. The result obtained, called the pound-second value, quantitatively expresses the integrated time-pressure relationship revealed graphically in the record. It, therefore, constitutes an index of the amount of work done by various parts of the foot. Complete analysis of each record, therefore, provides the following useful data:

1. A permanent record revealing qualitatively the interrelationships of time-pressure values over the six functionally important levels of each foot.
2. A quantitative comparison of the pressure sequence for the foot as a whole.
3. Definition of the pressure exerted through six levels of the foot under varying conditions.
4. An integration of the time-force components prevailing over these levels.

Each of these comparisons has its own particular significance and usefulness; the data selected are dependent upon the information sought.

Since space limitation precludes the possibility of including a complete analysis of the clinical examples herein presented, comparisons are made on the basis of changes in the average pressure values of the six levels recorded.

Although its many aspects are familiar to every one, human locomotion has, until recently, been defined by description and imitation rather than by reference to any specific quantitative standard. Moving pictures provide a method of visual comparison serving at best to preserve the appearance provoked by a given functional limitation without quantitative definition of its degree of departure from normal.

* From The Department of Surgery, Division of Orthopedics, The University of Rochester School of Medicine and Dentistry.

* Aided by a grant from The National Foundation for Infantile Paralysis, Inc.

1. Schwartz, R. Plato, and Heath, Arthur L.: The Definition of Human Locomotion on the Basis of Measurement with Description of Oscillographic Method, J. B. & Joint Surg. 29:203 (Jan.) 1947.

The purpose of this paper is the presentation of recorded evidence resulting from the application of instrumentation to the analysis of clinical problems. For reference purposes figure 1 includes a typical oscillographic record of a subject showing no visible evidence of functional disability, together with average pressure graphs for the stance phase of normal men and women.

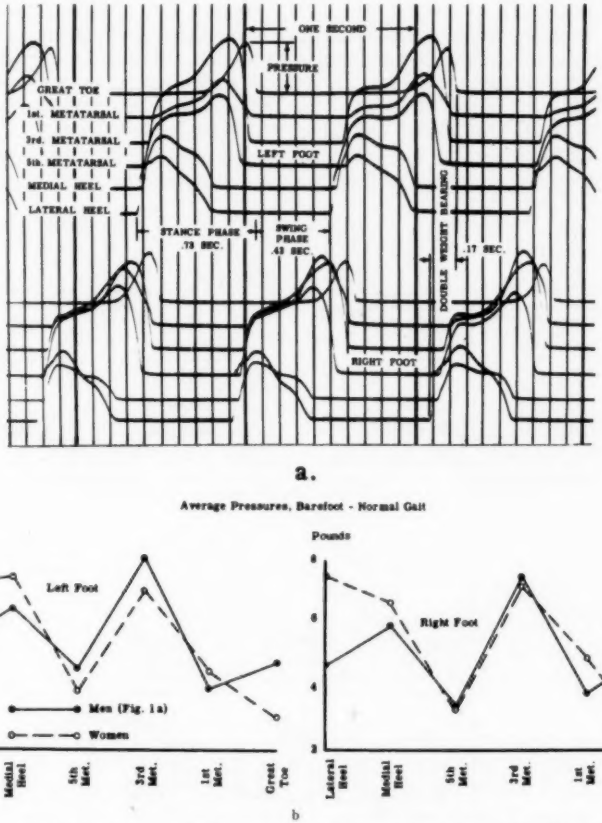

Fig. 1. — (*a*) Typical barefoot record with average normal time and sequence relationships defined. (*b*) Corresponding average pressure values for normal men and women.

As previously indicated,[2] three advantages are sought through the quantitative interpretation of records of human locomotion.

1. Measurement of the degree and extent of departure from normal locomotion prior to treatment.
2. Quantitative evaluation of progressive changes in locomotion resulting from applied therapeutic procedures.
3. Quantitative evaluation of the end result obtained as compared to the initial disability and to normal locomotion.

2. Schwartz, R. Plato, and Heath, Arthur L.: Foot Function Correlated with Anatomic, Clinical and Laboratory Data, New York State J. Med. 41:447 (March 1) 1941. Schwartz, R. Plato; Heath, Arthur L.; Brownell, Charles G., and Power, Walter C.: Useful Methods of Examination as Related to Cause and Treatment of Painful Feet, Physiotherapy Rev. 19:192 (Jan.-Feb.) 1939. Schwartz, R. Plato, and Heath, Arthur L.: Some Factors Which Influence the Balance of the Foot in Walking, J. Bone & Joint Surg. 19:431 (April) 1937.

The evidence herein presented reveals the degree to which present instrumentation fulfils these requirements.

Figure 2 reveals common characteristics of records of two patients deprived of effective use of the gastrocnemius and soleus. Uncomplicated ruptures of the left and the right tendo Achillis, respectively, are shown in figure 2*a* and 2*b*. Visual analysis of these records reveals that the major weight-bearing load is carried by the heel of the affected foot and that the propulsive effort normally exerted through the fore part of the foot is essentially absent. Inability to elevate the body weight onto the fore part of the foot is typical of any pathologic change that reduces the effective function of the gastrocnemius and soleus muscles in locomotion. The typical record pattern shown is easily identified with this functional limitation wherever seen.

Records presented in figure 2 also reveal the degree of compensatory function required of the unaffected opposite extremity. Comparison of the

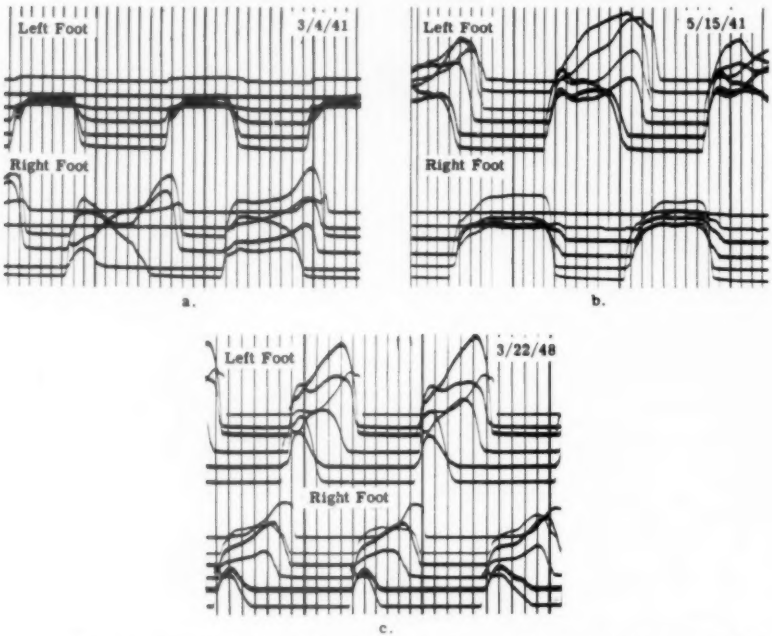

Fig. 2. — Similar functional limitations produce characteristic departures from normal gait pattern as illustrated by records of (*a*) left and (*b*) right hand Achillis (compare with figure 4*a*). (*c*) Functional improvement following repair of tendon of patient whose record is shown in (*b*).

analyses of feet with normal curves shown in figure 1 emphasizes the distortion of the normal pressure relationships.

Preoperative records shown in figure 2*b* were made on May 15, 1941. Records made seven years postoperatively (fig. 2*c*, March 24, 1948 reveal marked improvement in propulsive effort by the fore part of the foot. The recorded asymmetry in the gait pattern may result in part from an old fracture at the distal third of the right tibia. Roentgenograms reveal some posterior angulation at that level. The absence of gait records prior to May 15, 1941 makes it impossible to evaluate the functional importance of the old fracture.

Figure 4 reveals evidence of improvement in function during a ten-year period following severe impairment of the gastrocnemius and soleus muscles resulting from poliomyelitis. In 1937, at the age of 6, patient M. R. had poliomyelitis in the left lower extremity, with lasting effect in the gastrocnemius and soleus muscles. When first seen in the myodynamics laboratory on Jan. 9, 1939, clinical examination revealed (1) considerable atrophy of the left leg accompanied with ½ inch of shortening in the left lower extremity; (2) less atrophy in the thigh, with no functional limitation of the thigh muscles; (3) heel and midfoot weightbearing with essentially no propulsive effort expressed through the fore part of the foot and no cavus.

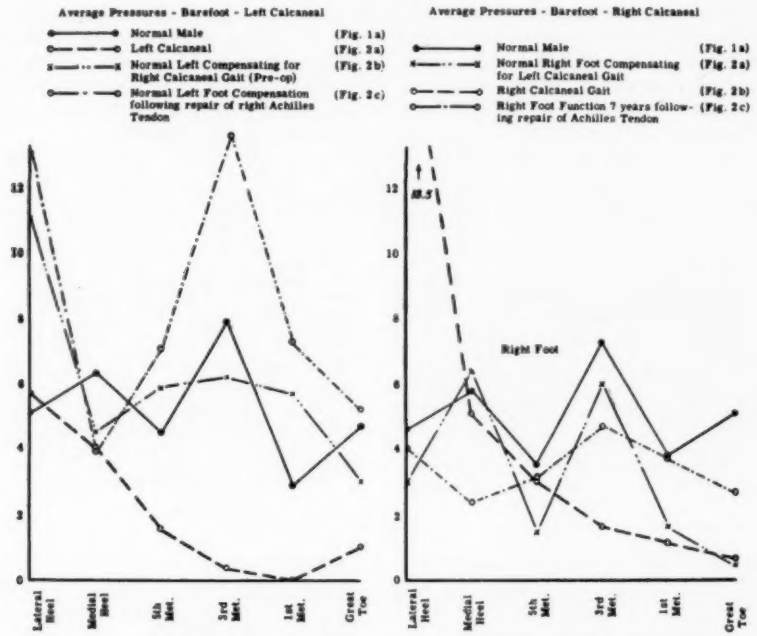
Average Pressures - Barefoot - Left Calcaneal
Normal Male (Fig. 1a)
Left Calcaneal (Fig. 2a)
Normal Left Compensating for Right Calcaneal Gait (Pre-op) (Fig. 2b)
Normal Left Foot Compensation following repair of right Achilles Tendon (Fig. 2c)
Average Pressures - Barefoot - Right Calcaneal
Normal Male (Fig. 1a)
Normal Right Foot Compensating for Left Calcaneal Gait (Fig. 2a)
Right Calcaneal Gait (Fig. 2b)
Right Foot Function 7 years following repair of Achilles Tendon (Fig. 2c)
12
10
8
6
4
2
0
Lateral Heel
Medial Heel
5th Met.
3rd Met.
1st Met.
Great Toe
Right Foot

Fig. 3. — Average pressure distortion in comparison with average male normal pressure values.

Therapy, including exercise, alterations of the shoe and the use of the blood pressure cuff was instituted. Since the patient was a nonresident, it was impossible to follow the course of treatment in specific detail.

Figure 4*a* reveals the degree of limitation in function recorded on Nov. 11, 1940. Typical heel and midfoot weight bearing is revealed with prolonged high level weight bearing on both lateral and medial heel contacts with no significant propulsive effort exerted by the forefoot. It is of interest to note that, while the cause of the disability differs from those presented in figure 2, the functional result — i. e., loss of power in the gastrocnemius and soleus — reveals the same functional limitation and the same gait pattern.

This patient was seen at three to six month intervals between 1940 and May 16, 1942, on which date records shown in figure 4*b* were made. Evidence of improvement of function is clearly seen in the increased weight bearing over the fifth metatarsal head and the beginning evidence of a more nearly normal weight-bearing pattern over the third metatarsal head, weight

bearing of recordable magnitude is shown over the first metatarsal head. On the unaffected right foot there is evidence of less need for compensatory action. Weight-bearing time on the left foot is 0.62 second, on the right 0.67 second.

In 1943, electromyograms revealed evidence of motor unit activity in the left gastrocnemius. Instruction was given to the patient in relation to the gait which would most effectively utilize any returning power in the gastrocnemius, with particular emphasis on equalizing the duration of weight bearing on the two feet and propulsion from the left forefoot. The purpose of such instruction was to attempt to overcome a forward shuffling of the weight without use of the forefoot which had become habitual during the early period of more complete dysfunction of the gastrocnemius and soleus muscles. Records made on April 28, 1944 are shown in figure *c*. These reveal evidence of further improvement as indicated by the following comparisons. There is an increase in the functional effectiveness of the fifth, third and first metatarsal heads as compared with the 1942 records. Not only are the pressures recorded of greater magnitude, but their timing indicates a rolling action from heel to forefoot as contrasted with the almost simultaneous reception of weight bearing shown in figure *b*. It is now pos-

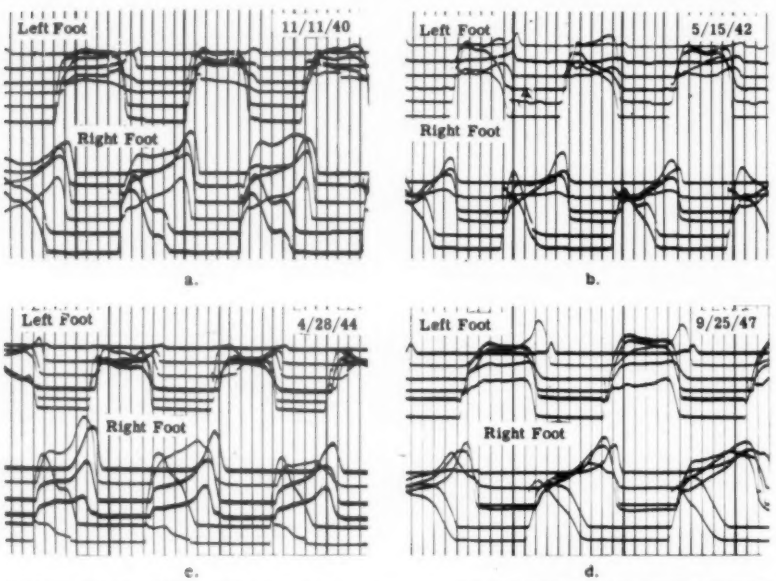

Fig. 4. — Recorded evidence of improvement in function over a ten year period following severe impairment of the gastrocnemius and soleus muscles resulting from poliomyelitis.

sible to divide the weight-bearing record of the left foot into definite heel and forefoot areas. Although the right foot record shows somewhat less stability than was evidenced in 1942, this appears to be the result of becoming accustomed to a more normal use of the left foot. The duration of the stance phase of the step on the left and right foot is now essentially equal with an average of 0.7 second spent on each foot.

Records made on Sept. 25, 1947 are presented in figure *d*. Additional advantage has been gained as indicated by the increased propulsive effort

exerted by the first metatarsal head and great toe. For the first time there is revealed consistent weight bearing over all six recorded areas of the foot. Continued evidence of prolonged weight bearing over the heels is seen in association with only partial regeneration of the gastrocnemius muscle. Nevertheless, the total pattern on both feet reveals far greater uniformity, stability and smoothness in gait than at any time since 1940. It is evident that the instability noted in the stance phase of the right foot in association with retraining in 1944 has been completely overcome as the new method of walking became habitual.

An interesting corollary to the poliomyelitis series presented in figure 4 is provided by patient B. M. (fig. 6). The clinical history, beginning in 1929, at which time the patient was 11 years of age, is essentially identical with that of the patient M. R. just presented. At that time the present instru-

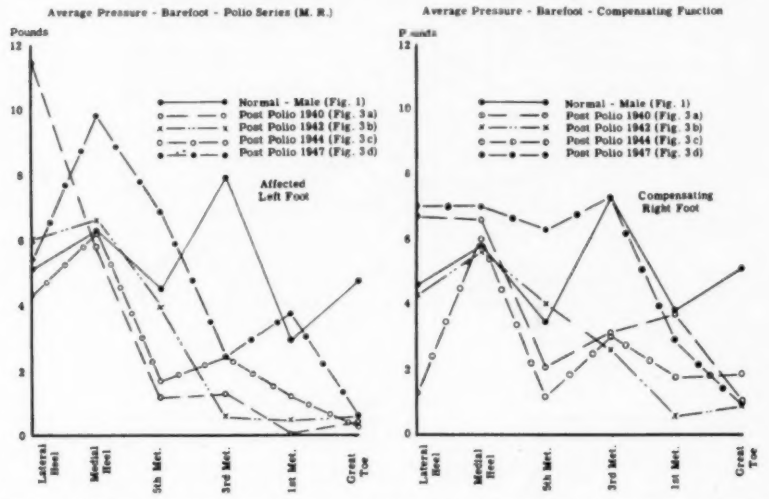

Fig. 5. — Changes in average pressure over a ten year period and comparison with normal male pressure values (from figure 4).

mentation had not been developed and could not, therefore, be applied to a preoperative determination of maximum disability. On the basis of clinical findings the decision was made to transplant the peroneal tendons into the tendo Achillis to compensate for loss of function in the gastrocnemius and soleus. Figure 6 reveals the end result seven years postoperatively. In the absence of preoperative records it is impossible to evaluate quantitatively individual degrees of initial disability. There is, however, no doubt of the similarity in the functional end result obtained in the two instances. Both reveal improvement in the propulsive function of the affected foot. Figure 6, however, reveals less effective use of the third and first metatarsal heads than that recorded in figure 4*d*.

Records thus far presented reveal distortions in the normal functional indices which are characteristic of a calcaneal gait. Of equal importance are the exaggerated pressure relationships of the forefoot in association with equinus gait. Figure 7*a* reveals distortion of the normal weight-bearing pattern of an 11 year old girl with congenital shortening of the left tendo Achillis. Absence of weight bearing on the heel portion of the foot is revealed

by flat base lines representing the lateral and medial heel areas, respectively. Minimum weight bearing over the first metatarsal head and the tip of the great toe indicates that this patient falls in the equinovarus group with significant weight bearing concentrated over the fifth and third metatarsal heads. Compensatory adaptation of the unaffected right foot is shown by the low, relatively uniform pressures exerted from heel to forefoot with absence of impact characteristics at the heel and with but minor propulsion through the forefoot. Stance duration on the left foot is one second, on the right 0.95 second.

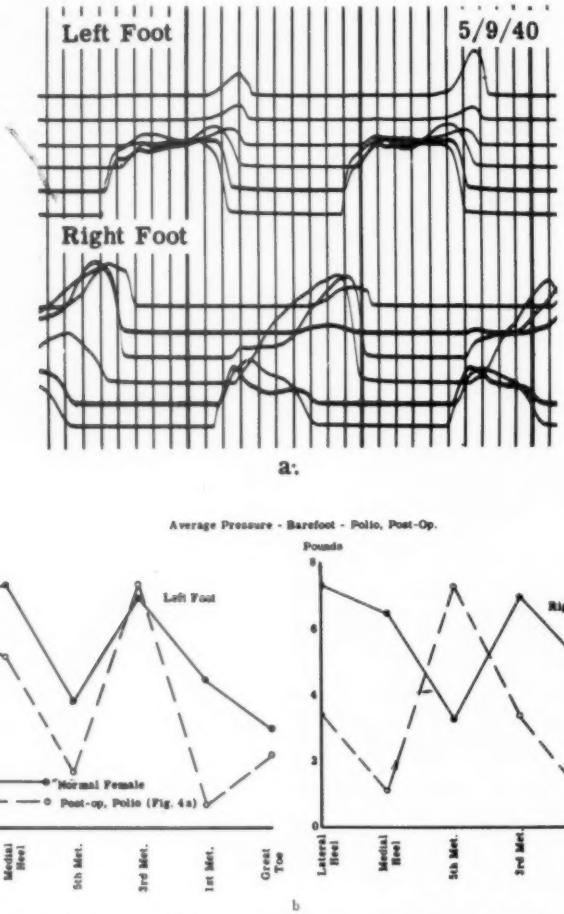

Fig. 6. — (a) Functional result of left peroneal transplant to compensate for loss of left gastrocnemius and soleus resulting from poliomyelitis. (b) Pressure values measured from (a) and compared with normal female average pressure graph.

On March 16, 1945 the left tendo Achillis was lengthened by operative procedure without complication. First postoperative records, made on May 9, 1945, reveal improvement in terms of complete function of the left foot from heel to great toe. The rate of walking was still below the average rate

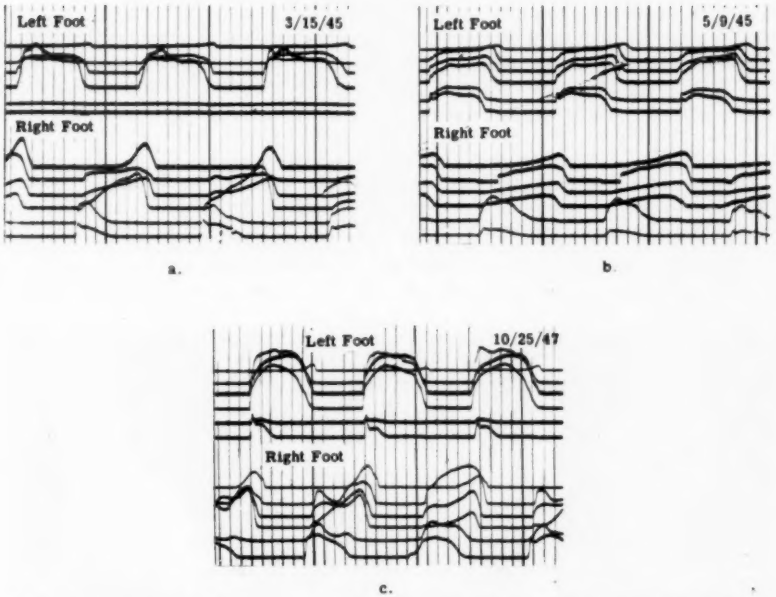

Fig. 7. — Records of (*a*) equinovarus gait resulting from short tendo Achillis; (*b*) seven weeks following operative lengthening of tendo Achillis, and (*c*) two and one-half years postoperatively.

of 1.8 steps per second, with a rate of 1.6 steps per second as compared to 1.42 steps per second on March 16, 1945. Evidence of more normal use of the unaffected right foot is seen in the distinct heel impact and increased time interval between reception of weight on the heel and the beginning of weight-bearing on the forefoot. Weight-bearing time on the left foot was 0.7 second, on the right 0.86 second. Record *7c* reveals the improvement in function

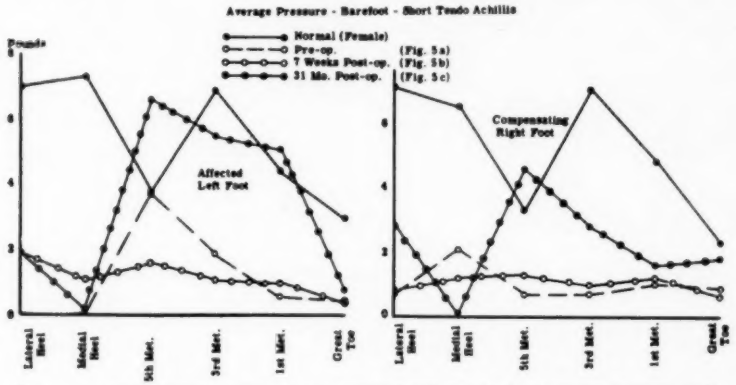

Fig. 8. — Average pressure values (fig. 7*a*) compared with normal female average pressure levels.

between May 9, 1945 and Oct. 25, 1947, as indicated by the increased rate of walking from 1.6 steps per second to 1.74 steps per second on the right. Evidence of more rapid roll from heel to forefoot on the left side is provided

by the decreased duration of the left heel contacts from 0.52 second to 0.23 second. Much improved weight bearing and propulsive effort is seen in relation to the left forefoot, although the heel and forefoot, except for the great toe, were still receiving weight essentially simultaneously. Compensatory function of the right foot has been reduced markedly over the 1945 record. In addition to defining the improvement made during the past two years, the 1947 records reveal the need for continued check on this child to obtain maximum advantage as a result of the tendon lengthening. Efforts will be made to develop a more rolling gait in which the weight is transferred successively from heel to forefoot.

Another example of the equinus gait is shown in figure 9. In this instance absence of weight bearing on the fifth metatarsal head with con-

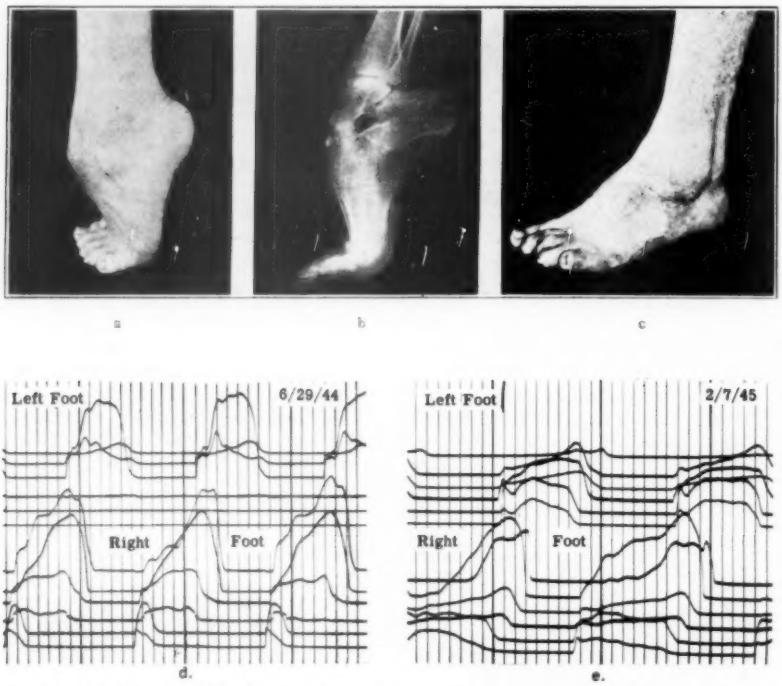

Fig. 9. — (*a*) Preoperative lateral view of left foot; (*b*) preoperative roentgenogram of left foot; (*c*) postoperative lateral view of left foot; (*d*) preoperative oscillographic gait record, and (*e*) postoperative oscillographic gait record.

centration of weight over the third and first metatarsals and great toe identify this gait as of the equinovalgus type. The subject, a 20 year old youth, had possessed this gross deformity since birth in association with cerebral palsy. The extent of the deformity (fig. 9 *a* and *b*) and the functional limitation (fig. 9*d*) were recorded on June 29, 1944.

On June 30, 1944 the deformity was corrected in association with a triple arthrodesis and operative lengthening of the tendon Achilles. The improved anatomic relationship of the foot to the leg is revealed in figure 9*c*. Record 9*e* shows the functional result eight months postoperatively. Marked im-

provement in function is shown by weight bearing on all six recorded levels of the left foot together with reduction of excessive pressure values over the left foot together with reduction of excessive pressure values over the left third metatarsal head. Step frequency was reduced from 1.45 to 1.08 steps per second. This undoubtedly resulted from the necessity of becoming accustomed to a totally new sequence of foot function and the need for establishment of a new reflex pattern.

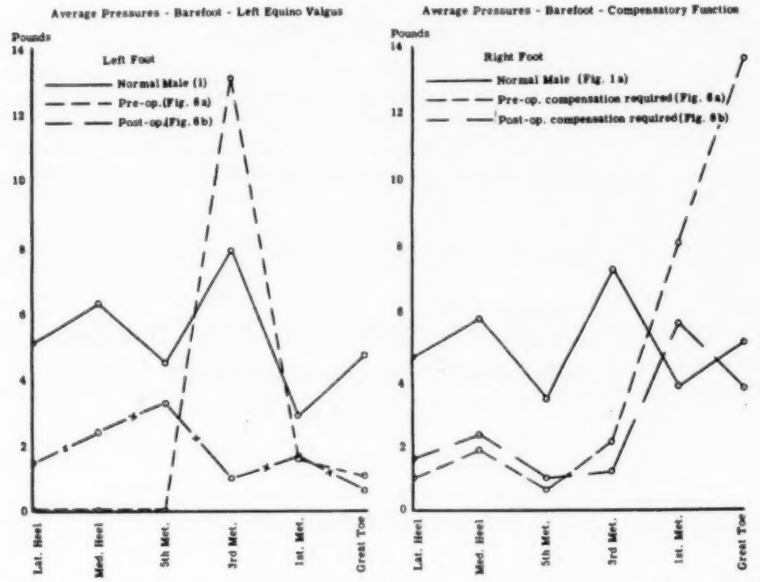

Fig. 10. — Average pressure graph of preoperative dysfunction and postoperative result (fig. 9 *d* and *e*) compared with normal male average pressure values.

Our initial objective was to make possible the recording and quantitative analysis of human locomotion.[3] Instruments and technic developed have been applied to clinical problems.[4] The gratification experienced in relation to the accomplishment of an objective is accompanied with a keen awareness that we have as yet only developed the tools with which to attack the problem. We look forward with confidence to more complete understanding of complexities of human locomotion through quantitative measurement.

Summary

1. A quantitative definition of normal human locomotion based on measurement of oscillographic recordings has been presented. Curves derived from a summation of forces were used to define the function of the foot as a unit.

3. Schwartz, R. Plato; Trautmann, O., and Heath, Arthur L.: Gait and Muscle Function as Recorded by the Electrobasogtaph, J. Bone & Joint Surg. **18**:454 (April) 1936; The Feet in Relation to the Mechanics of Human Locomotion, Physiotherapy Rev. **16**:46 (Mar.-Apr.) 1936. Schwartz, R. Plato; Heath, Arthur L., and Misiek, William: The Influence of the Shoe on Gait as Recorded by the Electrobasograph and Slow-Motion Moving Pictures, J. Bone & Joint Surg. **17**:406 (April) 1935.

4. Schwartz, R. Plato; Heath, Arthur L.; Misiek, William, and Wright, John N.: Kinetics of Human Gait: The Making and Interpretation of Electrobasographic Records of Gait: The Influence of Rate of Walking and the Height of Shoe Heel on Duration of Weight-Bearing on the Osseous Tripod of the Respective Feet, J. Bone & Joint Surg. **16**:343 (April) 1934. Schwartz, R. Plato; Heath, Arthur L., and Wright, John N.: The Electrobasographic Method of Recording Gait, Arch. Surg. **27**:926 (Nov.) 1933. Schwartz, R. Plato: The Foot and the Shoe, Physiotherapy Rev. **13**:105 (May-June) 1933.

2. Additional comparisons of average pressure and pound-seconds of work done at six levels of individual feet provides specific information regarding the function of various parts of the foot.

3. Comparisons of clinical records with normal standards provide a quantitative definition of malfunction.

4. Successive records made during the course of conservative treatment and preoperative and postoperative series of records provide quantitative evidence of the effectiveness of therapy.

5. Similar disabilities resulting from different causes produce records revealing readily identifiable departures from the normal record pattern.

6. A better understanding of the function and functional requirements of the normal foot can be most confidently provided through the application of quantitative measurement to the study of function of the foot.

7. It is now possible to define quantitatively the functional efficiency which is restored by therapeutic procedures as applied for the correction of a given disability.

THE INFLUENCE OF MECHOLYL AND HISTAMINE ION TRANSFER ON RECOVERY FROM FATIGUE *

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That the galvanic current may be used for the transport of medicinal substances through the intact skin has been known for the last half century. However, the technic of common ion transfer did not become clinically useful until the early 1930's. The administration of histamine acid phosphate by ion transfer was introduced in this country by Kling[1] in 1934. At approximately the same time Kovács[2] proposed ion of acetyl-beta-methylcholine chloride in the treatment of chronic arthritis and peripheral vascular disease. Subsequently, Kling and Sashin[3] advocated the administration of a combination of other drugs with histamine. In 1939 Kling[4] reported that

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Prof. L. E. A. Kelso of the Electrical Laboratory, School of Engineering, University of Wisconsin, devised the ergographs.

1. Kling, David H.: Treatment of Myositis, Arthritis and Disturbances of the Peripheral Circulation with Histamine by Cataphoresis, Arch. Surg. **29**:138 (July) 1934.
2. Kovacs, Joseph: The Iontophoresis of Acetyl-Beta-Methylcholine Chloride in the Treatment of Chronic Arthritis and Peripheral Vascular Disease, Am. J. M. Sc. **188**:32 (July) 1934.
3. Kling, David H., and Sashin, David: Histamine Iontophoresis in Rheumatic Conditions and Deficiencies of Peripheral Circulation, Arch Phys. Therapy **18**:333 (June) 1937.
4. Kling, David H.: A Histamine Ointment for Cataphoresis and Inunction in Rheumatic Affections and Diseases of the Peripheral Circulation, M. Rec. **150**:291 (Oct. 18) 1939.

imadyl unction, an ointment containing 1 per cent histamine dihydrochloride, methyl salicylate, synthetic methol, thymol and acetylglycosalicylic ester in an absorbable base, might be used as an efficient substitute for histamine solutions in ion transfer. Since then, the administration of mecholyl and histamine by ion transfer has been given extensive clinical trial. Both are powerful vasodilatants.[5] Histamine has, in addition, a pronounced capacity to reduce pain.

The beneficial affects purported to be produced by the administration of histamine or mecholyl by ion transfer are supported by a large body of clinical evidence. Appreciating that circulatory disturbances often accompany and aggravate rheumatoid arthritis, Boyd and his associates[6] administered large doses of mecholyl by ion transfer to patients with disabling joint disease. As a result there was striking relief of pain and improved ability to do work. The decreased fatigability was reported voluntarily and spontaneously. It was unanticipated. No such relief had been observed with other forms of treatment. The mechanism of the effect was unknown. Since then there have been repeated references in the clinical literature to the ability of mecholyl and histamine ion transfer to hasten recovery from fatigue. For the most part, this has been assumed to be secondary to the increased blood flow demonstrated by plethysmographic studies. However, it is not yet certain whether the effect is primarily cutaneous or too great to be due to increased blood flow in the superficial vessels alone. Thus, the contiguous muscles may or may not share in the benefits derived from the administration of vasodilatants by ion transfer. Whether or not augmentation of the blood flow to the muscles will increase the capacity to do work of the type used therapeutically is unknown. A priori reasoning suggests that this is improbable, since the fatigue of volitional effort is primarily central.[7] However, intense localized exercise may elicit transitory periarticular changes not unlike those associated with arthritis and alleviation of the discomfort elicited by these may explain the increased work capacity reported by Boyd. Because the restoration of work tolerance is of importance in the rehabilitation of the disabled, the efficacy of mecholyl or histamine as a recuperative was put to the test on normal subjects.

Methods

Three hundred and ten experiments were performed on 49 healthy adult women. A localized muscle group was fatigued by repetitive maximal isotonic contraction against heavy resistance. Work done was indicated by a modified Mosso ergograph. The prescribed exercise consisted of 20 bouts of voluntary serial contractions, executed at moderate speed to the rhythm of a metronome. Brief periods of rest, ranging from thirty to sixty seconds, were allowed between bouts. Rest pauses were held constant for any given subject. The exercise lasted approximately one-half hour and was characterized by a progressive decrement in work output. The work assignment was then repeated after a half hour rest period during which experimental or control procedures were introduced. In 1939, Foltz and Ivy[8] had suggested that the troublesome distorting

5. Montgomery, Hugh; Holling, Herbert Edward, and Friedland, Carl Kampton: The Effect of Iontophoresis with Acetyl-Beta-Methylcholine Chloride on the Rate of Peripheral Blood Flow, Am. J. M. Sc. **195**: 794 (June) 1938. Loman, Julius; Lesses, Mark Falcon, and Myerson, Abraham: Human Autonomic Pharmacology; XV. The Effect of Acetyl-Beta-Methylcholine Chloride (Mecholyl) by Iontophoresis on Arterial Hypertension, Ann. Int. Med. **12**:1213 (Feb.) 1939. Kling, David, H.: Response and Increase in Skin Temperature as Indicators of Efficiency of Vasodilating Drugs by Iontophoresis, Arch. Phys. Therapy **21**: 389 (July) 1940. Abramson, David I.; Fierst, Sidney M., and Flachs, Kamillo: Evaluation of the Local Vasodilator Effect of Acteyl-Beta-Methylcholine Chloride (Mecholyl) by Iontophoresis, Am. Heart J. **23**: 817 (June) 1942. Selle, W. A.: Histamine — Its Physiological, Pharmacological and Clinical Significance, Texas Rep. Biol. & Med. **4**:138 (Summer) 1946.

6. Boyd, Douglas; Osborne, Stafford L., and Markson, David E.: Treatment of Arthritis with Acetyl-Beta-Methylcholine Chloride, Arch. Phys. Therapy **20**:406 (July) 1939.

7. Reid, Charles: The Mechanism of Voluntary Muscular Fatigue, Quart. J. Exper. Physiol. **19**:17, 1928-29.

8. Foltz, E.; Ivy, A. C., and Barborka, C. J.: Use of Double Work Periods in the Study of Fatigue and the Influence of Caffeine on Recovery, Am. J. Physiol. **136**:79 (March) 1942.

effect of training might be minimized by performing double work bouts and accepting the relation of the second work bout to the first assignment as the criterion in terms of which to study the efficacy of supposedly restorative measures.

Experimental procedures consisted of ion transfer of 0.5 per cent mecholyl chloride or 1.0 per cent histamine ointment. Dosage was pushed to the limit of tolerance. If systemic reactions occurred, current intensity was reduced. Control observations were made with a placebo, imadyl unction containing no histamine, or by ion transfer with sodium chloride. In 90 additional control experiments no ion transfer was administered; the subject rested quietly during the half-hour interval between work assignments.

In the first series of 105 experiments, extremely heavy loads were carried and the duration of the effort per bout was the independent variable. In the second series of 125 experiments, the number of contractions per bout was held constant. An effort was made to select a load approximating the optimum capable of producing a complete ergographic fatigue curve in bouts consisting of 40 consecutive maximal contractions at the rate of 60 per minute. Thus, the first half of every experiment in this series consisted of 800 contractions divided into 20 bouts and lasting from 23 to 32 minutes, depending on the duration of the rest pauses. The total distance through which the load was lifted was the independent variable.

Work capacity was calculated in the usual way by multiplying the load lifted in any given experiment by the distance traversed. The first two series of experiments provided 9,200 ergograms, all of which were subjected to inspectional analysis. Thus, the efficacy of the procedure under investigation could be measured in terms of its influence on the slope gradient of the training curve, the significance of the difference in performance before and after the test procedure, the character of the ergogram or the signs and symptoms reported by the subject.

The first two series of experiments utilized the flexor digitorum sublimis of the middle finger of the preferred hand as the test muscle. These experiments were designed to produce the maximum tolerated peripheral effects. They were performed by a group of 9 trained and experienced subjects. The work done was sufficiently severe to produce acute manifestations of the "fatigue state" — namely, localized swelling and significant decrease in the facility of contraction. Tension, stiffness and pain were most evident during the terminal phases of the first exercise assignment and at the beginning of the second. The subjects were well trained and continued volitional effort in spite of discomfort. Complaint referable to muscle soreness per se was less frequently met than discomfort from the following complications: synovitis of the flexor tendons, long-lasting paresthesias of the exercised or contiguous supporting fingers, joint pain and the formation of blisters at the point of contact between the finger and the bellcrank of the ergograph against which the lifting force was applied. Thus, the major limitation to the severity of the exercise which could be tolerated by the trained and cooperative subjects participating in the first two series of experiments involved not the muscles concerned, but the resistance of the integuments, tendons, bones and joints to repeated microtrauma. In spite of the extreme severity of the work prescribed, in nearly all experiments recovery was essentially complete in the half-hour interposed between the two periods of exercise. The rest pause could not be shortened without reducing treatment to levels below those used clinically.

A final series of 80 observations was made on 40 untrained subjects. By substituting the radioulnar and wrist ergographs for the finger device, the complicating factors described above were largely eliminated. Each subject participating in the third series of experiments reported to the laboratory only three times. The first visit was devoted to the selection of individually adjusted work loads, sufficiently heavy to produce a complete fatigue curve in 40 consecutive contractions at the designated rhythm. The subject was indoctrinated relative to the importance of making an "all out" effort and was permitted to experience the sensations normally associated with medical galvanism. On the second visit, repetitive exhaustive work consisting of 20 consecutive bouts, separated by rest pauses of thirty seconds, was performed. The placebo ointment was then applied by ion transfer to the muscle groups being exercised. The work assignment was then repeated. On the final day, a 0.5 per cent aqueous solution of mecholyl chloride or a 1.0 per cent histamine unction was substituted for the placebo. The data collected on 34 of the 40 subjects were analyzed statistically. Six were excluded for one or more of the following reasons: poor coordination, lack of an "all-out" effort or instrumental limitations — inability to provide sufficient resistance to produce a degree of fatigue from which the subject could not recover completely in one-half

hour of time. In addition, each subject was interviewed immediately after the experiment and subjective reactions to the treatment were recorded.

Results and Their Interpretation

Table 1 presents the mean amount of work performed in the first and second series of repetitive bouts under control and experimental conditions for the three series of experiments.

TABLE 1. — *Average Work Done in Duplicate Functional Capacity Tests. The Second Test Was Performed One-Half Hour After the Termination of the First. The Experimental or Control Procedure Was Administered in the Interval Separating the Two Work Assignments.*

No. Experiments	Procedure	Test 1, Kg.	Test 2, Kg.	Difference, Kg.
Series I				
26	Resting control	21.21	18.81	—2.40
7	Histamine ion transfer	23.85	20.26	—3.59
26	Mecholyl ion transfer	24.69	24.31	—0.38
23	NaCl ion transfer	24.87	23.61	—1.26
Series II				
24	Resting control	43.21	42.44	—0.77
24	Histamine ion transfer	43.05	42.50	—0.55
21	Histamine ion transfer	39.85	39.87	+0.02
22	Mecholyl ion transfer	50.21	52.19	+1.98
22	NaCl ion transfer	47.86	48.67	+0.81
23	Placebo ungt. ion transfer	46.05	44.17	—1.87
Series III				
18	Histamine ion transfer	134.11	115.45	—18.66
16	Mecholyl ion transfer	110.94	91.99	—18.95
18	Placebo ungt. ion transfer	136.63	113.76	—22.87
16	Placebo ungt. ion transfer	100.50	83.45	—17.05

Regardless of the character of the procedure interposed between the duplicate tests, the difference in work capacity is small when compared with the magnitude of the effort. Attainment in the second test surpassed initial work capacity only in the histamine, mecholyl and sodium chloride ion transfer experiments of the second series. Of these, mecholyl ion transfer was associated with the greatest degree of restoration, the difference in work capacity in the two tests, +1.98 Kgm., having a probability level of .20. Although this is not generally considered statistically significant, it approaches significance. Thus, of all procedures tested, only mecholyl may have had a recuperative effect above and beyond that attainable through rest alone.

To evaluate the comparative effects of the experimental and control procedures upon recovery from fatigue, the experiments in each series were paired and the reliability of the difference in recovery was estimated (table 2).

In the first series of experiments, significant differences are to be noted between the magnitude of recovery following the resting control compared with mecholyl ion transfer, and between the resting control and sodium chloride ion transfer. Although statistical comparison of the histamine and mecholyl experiments indicates an obviously greater recovery following mecholyl ion transfer, too few experiments were carried out to permit one to consider the evidence conclusive.

In the second series of studies, in which a larger number of experiments were performed and for which trained subjects were available, every combination in which mecholyl ion transfer was one of the paired procedures subjected to statistical analysis, it demonstrated itself to be more restorative

than histamine. However, the difference in work output was significant statistically only when recovery following mecholyl ion transfer was compared with that associated with the administration of the placebo ointment. Its superior recuperative effect approached the significant level when compared with that of the resting control and histamine ion transfer. On the other hand, the differences in restoration of work capacity following the administration of histamine were so small as to be of no significance.

TABLE 2. — *Reliability of Differences in Work Output Following the Administration of Vasodilatants and Various Control Procedures.*

No. Experiments	Procedures 1	Procedures 2	Differences[a] M_1-M_2	Level of Probability
Series I				
7	Rest	Histamine	—0.45	0.70
26	Rest	Mecholyl	+2.09	0.01
23	Rest	NaCl	+1.62	0.05
5	Histamine	Mecholyl	+3.44	0.20
4	Histamine	NaCl	+0.34	0.80
19	Mecholyl	NaCl	—0.69	0.40
Series II				
24	Rest	Histamine	+0.22	0.90
22	Rest	Mecholyl	+2.76	0.27
22	Rest	NaCl	+1.59	0.56
23	Rest	Placebo ungt.	—1.24	0.65
21	Histamine	Mecholyl	+2.00	0.30
21	Histamine	NaCl	+0.63	0.80
21	Histamine	Placebo ungt.	—2.06	0.30
22	Mecholyl	NaCl	—1.17	0.45
22	Mecholyl	Placebo ungt.	—3.92	0.05
22	Placebo ungt.	NaCl	—2.76	0.20
Series III				
18	Histamine	Placebo ungt.	—4.21	0.50
16	Mecholyl	Placebo ungt.	+1.90	0.60

[a] M_1-M_2 = Mean difference in work capacity (Kg). Plus indicates that the second (2) procedure of the paired experiments produced a greater recovery from fatigue than the first (1) procedure. Minus indicates that less work was done after the second of the paired procedures.

The experiments of the third series did not confirm those of the first two, except that recovery from fatigue was slightly better in the group treated with mecholyl than that given histamine ion transfer (table 1). As already suggested, the novices who comprised the experimental group for the third series of studies were less reliable judges of an "all-out" effort than those inured to the discomforts of hard work by systematic training.

Although the evidence indicates that mecholyl chloride has what approaches a significantly greater recuperative effect on experimentally induced fatigue than does histamine ion transfer, neither restores work capacity to any notable degree. The effect of mecholyl approaches but does not reach unequivocal significance. Thus, the numerical evidence presented is in accord with our more qualitative preliminary analyses of the data.[9]

Seventy-five per cent of the 20 subjects of the third series of experiments to whom histamine ion transfer was administered and who were questioned relative to their subjective reactions reported less fatigue following this than when a placebo ointment was substituted; 70 per cent to whom mecholyl was administered responded similarly. The trained subjects likewise reported relief from discomfort when histamine or mecholyl was introduced by ion transfer in the interval between duplicate work assignments. The

9. Hellebrandt, F. A.; Houtz, Sara Jane, and Duvall, Ellen Neall: The Influence of Mecholyl and Histamine Iontophoresis on Recovery from Fatigue, Federation Proc. 6:127 (March) 1947. Parrish, A. M.; Skowlund, H. V., and Duvall, E. N.: The Influence of Vasodilator Drugs on Recovery from Fatigue, Proc. Virginia Acad. Sc. 1946-1947, p. 113.

tense and painful forearm became warm and supple, and swelling was reduced. However, in spite of the subjective improvement, there was no great difference between the magnitude of recovery in work capacity.

The observations presented argue against the importance of all peripheral components in fatigue related to adequacy of circulation. They argue also against the importance of nociceptive afferent impulses emanating from the parts activated by muscular contraction. In 1928-1929, Reid[9] demonstrated that it was impossible to induce complete fatigue in the normal muscle of man with an intact blood supply when subjected to electrical stimulation eighty times a minute for two hours. However, volitional contraction induced complete fatigue in a matter of minutes. The failure of response to voluntary effort could not be accounted for adequately by changes in peripheral excitability or muscular contractility. Reid, therefore, concluded that the fatigue of volitional effort is primarily central and is affected by inhibitory impulses arising in the muscles themselves. Gellhorn[10] has since postulated that if a limb is rendered ischemic, the resulting disturbance in muscular action is due to modification in cortical innervation by pain afferents rather than circulatory changes. How inhibiting such nociceptive stimuli will be, must vary in different persons. Most of the experiments reported in our study were performed by subjects trained to endure the discomforts which always accompany severe exercise. Thus, the will to work may be said to dominate the overt response of our subjects and minimize the augmenting influence of the alleviation of pain by mecholyl or histamine ion transfer.

Summary and Conclusions

Three hundred and ten ergographic experiments, designed to test the influence of mecholyl and histamine ion transfer on recovery from fatigue, were performed on 9 trained and 40 untrained subjects. Double periods of exhausting repetitive voluntary work were performed on the finger, radioulnar and wrist ergographs. Experimental or control procedures were introduced during the one-half hour period which intervened between the first and second "all-out" effort. The evidence presented supports the following conclusions:

1. The administration of mecholyl chloride by ion transfer has a significantly greater effect upon recovery from experimentally induced fatigue than histamine or sodium chloride by ion transfer or rest.

2. The magnitude of the recuperative effect of mecholyl approaches but does not reach unequivocal significance.

3. The subjective fatigue-alleviating effects purported to be produced by the clinical administration of vasodilating drugs by ion transfer were confirmed on normal subjects.

4. The volitional outgoing motor impulses of subjects willing to make a maximal "all-out" effort are not sufficiently affected by a diminuation in inhibitory nociceptive impulses as a result of histamine or mecholyl ion transfer to augment work output greatly.

10. Gellhorn, E., and Thompson, L.: Muscle Pain, Tendon Reflexes, and Muscular Coordination in Man, Proc. Soc. Exper. Biol. & Med. 56:209 (June) 1944.

THERMAL GRADIENTS IN MAN

Comparison of Temperatures in the Femoral Artery and Femoral Vein With Rectal Temperatures *

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NEW YORK

Homeothermic man maintains the temperature of his body, or of some critical part of it, at a relatively fixed level under normally varying conditions of metabolic activity and climatic variation. Small changes in temperature of these critical, probably deep, tissues initiate compensatory adjustments which return the temperature to the normal level. The critical deep tissue and its temperature variations which are responsible for these readjustments are still the subject of study. Usually rectal temperature has been accepted as representative of deep tissue temperature and of its changes, but this has not been completely established and in some circumstances may be questioned. It seems desirable, therefore, to undertake the study of other, perhaps more representative, deep tissue temperatures. To this end comparisons were made of the temperatures in the femoral artery and vein with rectal temperature under varying conditions of body temperature.

The temperature of femoral arterial blood was chosen for study because, on theoretical grounds, it should approximate closely the temperature of the blood in the left ventricle, which, in turn, may be considered representative of the weighted average temperature of the mixed blood of the body. Within the left ventricle the blood from all organs of the body is mixed, probably in proportion to the blood flow from each organ and the temperature of the blood from each. The result is a weighted average temperature representative of all of the blood. Three factors reduce markedly the opportunity for a change in temperature of the blood during transit from the left ventricle to the femoral artery: (1) the rapid flow of blood through the aorta to the femoral artery, (2) the enclosure of the aorta and iliac arteries within a body cavity the temperature of which is very nearly the same as that of the vessels themselves and (3) the poor specific thermal conductivity of tissues (approximately that of wood). For these reasons the temperature of femoral arterial blood may be considered to approximate closely the temperature of left ventricular blood and consequently of the blood as it enters the deep tissues of the body.

Methods

All temperatures were determined by copper-constantan thermocouples. Their electrical potentials were measured by a type K2 Leeds and Northrup potentiometer and converted to temperatures by calibration coefficients determined under conditions reproducing those under which the thermocouples were used. All thermocouple junctions were of small mass, had rapid response times (95 per cent of full response in ten to fifteen seconds) and stable calibrations. The rectal thermocouple consisted of one copper and one constantan wire, each gauge 30, presenting on the lateral wall of a bulbous plastic (Lucite) applicator which carried the thermal junction 2 inches above

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the anal orifice. Intravascular temperatures were measured by thermocouples threaded through needles previously introduced into the femoral artery and vein.[1] The first intravascular thermocouples consisted of stylets made of one gauge 42 copper wire and one gauge 30 constantan wire threaded into a gauge 22 needle and soldered at the needle tip. These "needle" thermocouples fitted into regular gauge 18 needles, and their sensitive tips came flush with the tip of the cannulating needle. Because of the possibility that the needle thermocouples might puncture their way out of the vascular lumen, they were replaced by "plastic" thermocouples with which most of the measurements were made. These thermocouples consisted of one gauge 42 copper wire and one gauge 30 constantan wire threaded through very narrow-bored polyvinyl tubing and soldered at the tip. When fully threaded through indwelling gauge 18 Cournand needles, their thermal junctions extended, in the lumen of the vessel, for 1.5 cm. to 8.0 cm. beyond the tip of the needle. The two types of thermocouples gave similar results, and the data obtained by the two are considered together. Muscle temperatures at a depth of 1½ inches beneath the skin surface and subcutaneous tissue temperatures just under the skin were determined in the lateral aspect of the thigh with needle thermocouples similar to those already described.

Since even the smallest movement of the thermal junction out of the vascular lumen produced rapid and marked drops in temperature, several precautions were taken to insure that temperatures of femoral arterial and venous blood were actually being measured. The thermocouples were threaded through cannulating needles only when blood was flowing freely from them — spurting bright red blood in case of the femoral artery and dripping dark blood in case of the femoral vein. Moreover, the plastic thermocouples were always longer than the puncturing needle and were required to thread easily to their full length, thus insuring that the thermal junction was well within the vessel. In the femoral vein slight fluctuations in the temperature readings, phasic with respiration, provided a helpful, though not constant, hint that the thermal junction was within the vessel.

Hospital patients served as subjects and may be divided into three groups: (1) ambulatory patients with normal temperatures and essentially fully recovered from their immediate illnesses (included in the table under the heading Normal Temperature—Ambulatory Subjects); (2) patients with normal temperatures but with chronic illnesses which made them bedfast (Normal Temperature — Ill Subjects); (3) patients with non-infectious fever, of whom all were very ill and all but 1 subsequently died. The subjects were nude, except for a towel over the genitalia, during the observations, which were made in a warm room.

Results

The table gives the simultaneously determined rectal, femoral arterial blood, and femoral venous blood temperatures of all subjects. Chart 1 indicates the deviations of the femoral arterial blood temperatures from the rectal temperatures and chart 2 the deviation of the femoral venous blood temperatures from the femoral arterial blood temperatures. These measurements were made in the "resting" state, except in subjects Oc, Ta and So, who had previously received cooling agents to the skin to lower elevated body temperatures. Generally, the femoral arterial blood temperature fell slightly, but significantly, below rectal temperature and the femoral venous blood temperature fell to varying degrees below the femoral arterial blood temperature. In the ambulatory afebrile subjects, the femoral arterial blood temperature averaged 0.32 degree C. (0.6 degree F.) below rectal temperature. In the febrile subjects this difference was greater and averaged 0.61 degree C. (1.1 degree F.) below rectal temperature. The femoral venous blood temperature was 0.45 degree C. (0.9 degree F.) below femoral arterial blood temperature in the ambulatory afebrile subjects and 0.37 degree C. (0.7 degree F.) below in the febrile subjects.

The 4 subjects in group 2, "Normal Temperature — Ill Subjects," differed conspicuously from the ambulatory afebrile and from the febrile sub-

1. (a) Bazett, H. C.; Love, L.; Mendelson, E. S., and Peterson, L. H.: Arterial Temperatures in Man, Federation Proceedings 6:76 (March) 1947. (b) Eisenberg, L., and Bazett, H. C.: Further Observations on Intravascular Temperatures in Man, Federation Proceedings 7:30 (March) 1948. (c) Bazett, H. C.; Love, L.; Newton, M.; Eisenberg, L.; Day, R., and Forster, R. II: Temperature Changes in Blood Flowing in Arteries and Veins in Man, J. Applied Physiol. 1:3 (July) 1948.

jects in that their femoral arterial blood temperatures equaled their rectal temperatures. In contrast to the outwardly well appearance of the ambulatory afebrile group, these subjects presented a uniform picture of chronic illness with weight loss, debility and anemia. Three of the 4 died of their disease shortly after the observations were made. No explanation is offered for their

TABLE I

Relationship Between Rectal, Femoral Arterial and Femoral Venous Temperatures

Subject	Sex	Diagnosis	Rectal Temp. (Tr) °C	°F	Femoral Arterial Temp. (Tfa) °C	°F	Femoral Vein Temp. (Tfv) °C	°F	Differences Tr — Tfa °C	Tfa — Tfv °C
		Normal Temp. — Ambulatory Subjects								
Wh	M	Vagabondia	36.57	97.8	36.41	97.5	35.50	95.9	+0.16	+0.91
Ma	M	Cor pulmonale	37.23	99.0	36.74	98.1	36.37	97.5	+0.49	+0.37
Ro	M	Postpneumonia	37.38	99.3	37.11	98.8	36.54	97.8	+0.27	+0.57
Kn	M	Healed tuberculosis	37.43	99.4	37.19	98.9	36.86	98.4	+0.24	+0.33
Du	F	Congenital heart disease	37.53	99.6	37.09	98.8	.....	.....	+0.44	.....
Sl	M	Psychosis	37.56	99.6	37.30	99.1	37.20	99.0	+0.26	+0.10
Pi	M	Central nervous system syphilis	37.62	99.7	37.29	99.1	36.99	98.6	+0.33	+0.30
Or	M	Post-traumatic	37.98	100.4	37.72	99.9	37.11	98.8	+0.26	+0.61
Ha	M	Peripheral neuritis	38.03	100.4	37.59	99.7	.....	.....	+0.44	.....
Average		.....	.....	.....	.....	.....	.....	.....	+0.32	+0.45
		Normal Temp. — Ill Subjects								
We	M	Gastric carcinoma	36.58	97.8	36.63	97.9	35.85	96.5	—0.05	+0.78
Oc	F	Pyelonephritis	37.13	98.8	37.13	98.8	36.94	98.5	0.00	+0.19
Gl	M	Pancreatic carcinoma	37.37	99.3	37.40	99.3	36.27	97.3	—0.03	+1.13
Au	M	Cirrhosis	37.51	99.5	37.45	99.4	37.12	98.8	0.06	+0.33
Average		.....	.....	.....	.....	.....	.....	.....	0.00	+0.61
		Non-Infectious Fever								
Bi	M	Undiagnosed	38.98	102.2	38.41	101.2	37.39	99.3	+0.57	+1.02
Ta	M	Arteriosclerosis	39.62	103.3	39.40	102.9	38.87	102.0	+0.22	+0.53
Hu	F	Post central nervous system, surgery	39.64	103.4	39.09	102.4	39.08	102.3	+0.55	+0.01
Ad	M	Bromide intoxication	40.30	104.6	39.93	103.9	39.93	103.9	+0.37	0.00
Sc	M	Delirium tremens	40.46	104.8	39.68	103.4	39.40	102.9	+0.78	+0.28
So	F	Carbon dioxide poisoning	41.67	107.0	40.50	104.9	.....	.....	+1.17	.....
Average		.....	.....	.....	.....	.....	.....	.....	+0.61	+0.37

different temperature pattern. The relationship of their femoral venous blood temperature to the arterial blood temperature was the same as in the other two groups.

In normal subject Ha two thermocouples were introduced into the same femoral artery through separate needles puncturing the artery at approximately the same level. One thermocouple extended 2.5 cm. beyond the tip of the needle, the other thermocouple extended 8.0 cm. beyond the tip of its needle. The two thermocouples gave the same temperature reading, 37.59 C. (99.7 F.), which was 0.44 degree C. (0.8 degree F.) below the rectal tem-

perature at the time (table). Within the distance of 6 cm. there was no temperature gradient in the femoral artery.

Observations were made to follow the relationships of the rectal, femoral arterial and femoral venous blood temperatures to each other during variations in body tmperature.

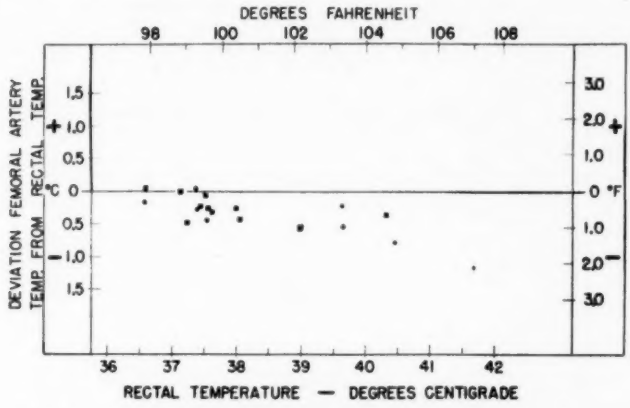

Chart 1. — Relationship between simultaneously determined femoral arterial blood temperature and rectal temperature. Closed circles indicate determination made with needle intravascular thermocouples; crosses indicate determinations made with plastic tubing intravascular thermocouples.

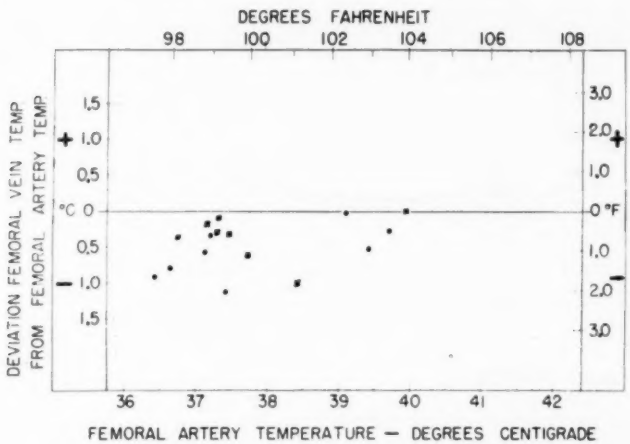

Chart 2. — Relationship between simultaneously determined femoral venous blood temperature and femoral arterial blood temperature. Closed circles indicate determinations made with needle intravascular thermocouples; crosses indicate determinations made with plastic tubing intravascular thermocouples.

Normal subjects were warmed with heating pads and blankets until they were perspiring freely and then were cooled by allowing the sweat to evaporate from their nude bodies. One type of response is indicated in chart 3. The rise in subcutaneous tissue temperature, and to a smaller extent in muscle temperature, indicates that the peripheral tissues accumulated heat but there

was little change in rectal, femoral arterial blood and femoral venous blood temperatures or in the relationship of these three temperatures to one another. Such changes as did occur in these temperatures were of the type much more clearly demonstrated by chart 4. In this case one of the heating pads was placed over the popliteal vessels and the lower leg of the side on

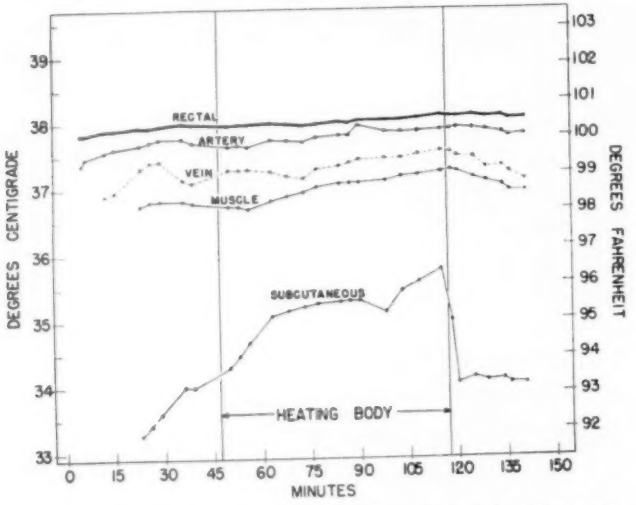

Chart 3. — Relationship of the changes in rectal, femoral arterial, femoral venous, intramuscular and subcutaneous temperatures during warming and subsequent cooling of the body. Heating of the body was accomplished with blankets and heating pads.

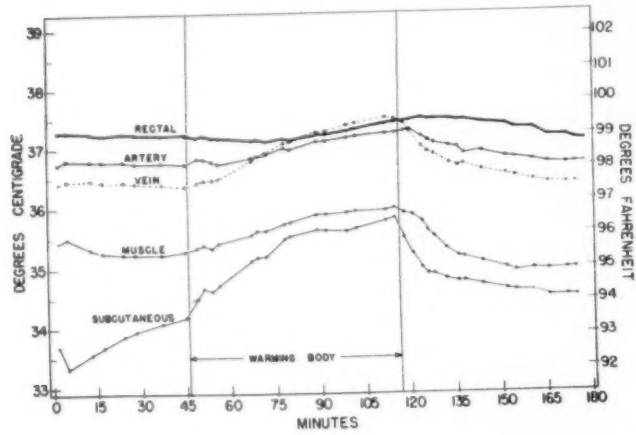

Chart 4. — Relationship of the changes in rectal, femoral arterial, femoral venous, intramuscular and subcutaneous temperatures during warming and subsequent cooling of the body. The body was warmed with blankets and heating pads. One pad was placed on the leg on the one side where intravascular temperatures were measured.

which intrafemoral vascular temperatures were measured. Variations of considerable magnitude developed in the relationship of the several temperatures to each other during the changing body temperature (chart 4). Femoral

venous blood temperature rose and fell sharply during the heating and cooling periods and during the height of the heating period exceeded both the rectal temperature and the femoral arterial blood temperature. Femoral arterial blood temperature changed concomitantly with that of the femoral vein and in the same direction, but to a less extent. At the peak of heating,

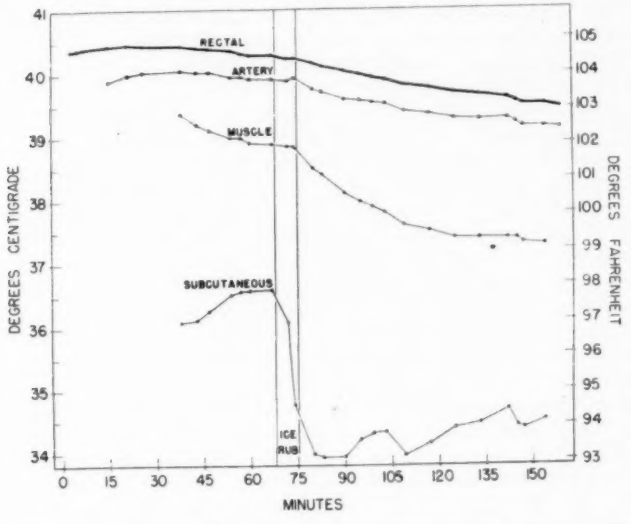

Chart 5. — Relationship of the changes in rectal, femoral arterial, intramuscular and subcutaneous temperatures during cooling of the body with ice.

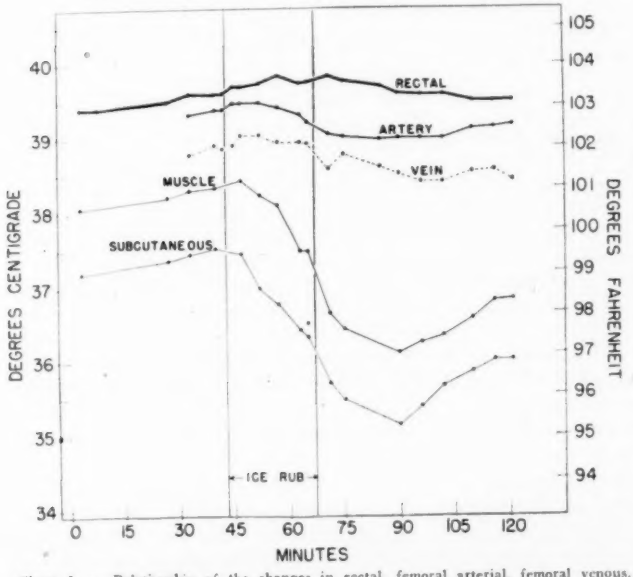

Chart 6. — Relationship of the changes in rectal, femoral arterial, femoral venous, intramuscular and subcutaneous temperatures during cooling of the body with ice.

femoral arterial temperature approached considerably closer to rectal temperature than during the control and cooling periods. Throughout the procedure rectal temperature changed but little and lagged considerably behind the changes in intrafemoral vascular temperatures. As a result, the rectal and intravascular temperatures on occasion were moving in opposite directions. Thus, at the beginning of the warming period the rectal temperature actually fell slightly as the femoral arterial blood temperature was beginning to rise, and at the beginning of the cooling period the rectal temperature was still rising slightly, whereas the femoral arterial blood temperature had already begun to fall (chart 4).

Analogous results were observed during the lowering of the body temperature of febrile subjects by the application of cooling agents to the skin. Chart 5 indicates an instance in which the rectal temperature and femoral arterial blood temperature fell concomitantly and in a parallel fashion. As a result, the initial relationship of the two temperatures to each other was retained during a drop of 2 degrees F. in rectal temperature. In this regard, the temperatures of Oc (table 1) were measured two and one-half hours after therapeutic cooling had abruptly lowered the rectal temperature from 41.7 C. (107 F.) to 36.1 C. (97 F.); the femoral arterial blood temperature was the same as the rectal temperature. Chart 6 is an example of an instance in which, at times, rectal temperature and femoral arterial blood temperature changed independently. During active cooling, the blood temperature fell while rectal temperature continued to rise slowly, producing thereby an increase in the difference between these two temperatures. Again after the cooling procedure, the two temperatures moved in opposite directions: the rectal temperature fell while the femoral arterial blood temperature remained stabilized. Finally, the lagging fall in rectal temperature ultimately returned the relationship between the two temperatures to that present initially (chart 6).

The tendency of the rectal temperature to lag behind the femoral arterial blood temperature during changes in body temperature may account for the scatter in the deviation of femoral arterial blood temperature from rectal temperature indicated in chart 1.

Comment

These observations indicate that in a relatively steady state the femoral arterial blood temperature is slightly, but significantly, lower than the rectal temperature and that during changing body temperature the rectal temperature may lag behind the changes in femoral arterial blood temperature, even to the extent, at times, of changing in an opposite direction. If one accepts the femoral arterial blood temperature as representative of the weighted average, mixed blood temperature and the rectal temperature as the temperature of one organ, then these differences in magnitude and behavior of the two temperatures become explicable, in that the same temperature is not being measured and therefore the values need not be the same. A change in temperature of the blood flowing through one organ may alter the temperature of the mixed blood, whereas the rectal temperature need not change until the temperature of the rectum has been altered by perfusion with blood at the new temperature.

It is, nevertheless, striking that the rectal temperature should so generally exceed "mixed" blood temperature, as represented by femoral arterial blood temperature. It is understandable that an organ with high metabolic activity and heat production should have a higher temperature than an organ (blood) which, at least to some extent, summates the temperatures of all

organs. One does not think of the rectum as a site of high metabolic activity, and if its temperature represents merely the lagging temperature of some previous mixed blood temperature one would expect in random sampling to find rectal temperature below, as well as above, femoral arterial blood temperature. Bazett, Love, Newton, Eisenberg, Day and Forster[1c] have shown that in the extremities arterial blood temperature might be lowered by the cold blood flowing in the adjacent veins. However, sizable falls in arterial temperature occurred only when the room temperature was low and therefore the returning venous blood quite cold. Since the present observations were made in a warm room, with the subjects comfortably warm, it is unlikely that such a mechanism accounted for the low femoral arterial blood temperatures in our observations. It remains for measurements of intracardiac temperatures simultaneously with rectal and femoral arterial blood temperature as representative of mixed blood temperature to establish mixed blood temperature as lower than rectal temperature.

For clinical purposes, the differences between rectal and femoral arterial blood temperatures were not sufficiently great to be of practical importance. In no instance in this study would a patient's classification as febrile or afebrile be altered by either of the temperatures. However, in some febrile patients the femoral arterial blood temperature deviated from the rectal temperature to such an extent (degrees F.), particularly during changing body temperature, as to give a distinctly different notion of the degree of fever present.

The difference between rectal temperature and femoral arterial blood temperature, both in magnitude and in rate of change, appear quite significant for certain physiologic considerations, particularly those dealing with blood flow to organs and with thermal homeostasis of the body. Certainly physiologic technics which utilize temperature measurements to determine blood flow and assume that afferent blood is at rectal temperature appear open to errors, both in the magnitude of their blood flow estimations and in the time relationships of their changes. In regard to thermal homeostasis of the body, rectal temperature has often been considered representative of the temperature of the critical deep tissue which "triggers" adjusting mechanisms. One may question whether the mixed blood temperature, possibly represented by the femoral arterial blood temperature, is not more significant in this respect. Any opinion now would be highly speculative until more is known concerning the critical deep tissue and its temperatures. However, the temperature of the blood entering this critical tissue is more likely to be represented by femoral arterial blood temperature than by rectal temperature.

Summary

The temperatures of the blood in the femoral artery and femoral vein were measured simultaneously with the rectal temperature in 13 patients with normal rectal temperatures and in 6 patients with elevated rectal temperatures.

The femoral arterial blood temperature was generally lower than the rectal temperature in both afebrile (by 0.3 degree C.) and febrile (by 0.6 degree C.) subjects.

During both increasing and decreasing body temperatures, the femoral arterial blood temperature and the rectal temperature at times moved in a parallel fashion and at other times deviated from each other, owing largely to a lag, and even a movement in the opposite direction, of the rectal temperature.

The differences in femoral arterial blood temperature and rectal tem-

perature were not of such magnitude as to be of practical clinical significance but were sufficiently great to suggest a reexamination of those technics for the measurement of blood flow to organs which assume that rectal temperature indicates the temperature of inflowing blood and a review of those concepts which suggest that rectal temperature represents the critical temperature which initiates the adaptive mechanisms of thermal homeostasis.

Discussion

Dr. Steven M. Horvath (Philadelphia): Dr. Eichna's paper brings vividly to mind of all physiologists and to all clinicians a very important comment made seventy years ago by Claude Bernard. At that time, when he first demonstrated in lower animals, of course, that there is a striking difference in temperature at various parts of the vascular tree and that there is a difference also between the temperature of the rectum and the temperature at various parts of the body, he pointed out that "modern medicine" could not develop very far without first appreciating and studying the relationships between all parts and their reactions to both environment and internal stresses.

I believe now that the tools which Dr. Eichna has so practically employed in presenting this material today illustrate very clearly the value to be obtained by such a comprehensive evaluation of the stresses imposed on man by thermal agents such as are used commonly in physical medicine.

Unfortunately, Dr. Eichna has left us in quite a predicament. For a long time we have used oral temperatures; then we used the axillary temperature, and now we use the rectal temperature as an indication of what happens to the body temperature. He leaves us with practically no alternative but to assume that the venous jugular temperature is the only temperature which can be utilized to evaluate. Although he has not mentioned this possibility it is only a suggestion on my part — the jugular temperature may be the only temperature which would indicate the temperature which determines the thermal regulatory responses of the body.

For many years I have been opposed to any suggestion that oral temperature is of value in estimating body temperature. (Maybe, after all, oral temperature may not be such a bad measure of body temperature.) Actually, I wish that Dr. Eichna had presented some oral temperatures because, in general, their differences from rectal temperature are in somewhat the same category as are the differences between the femoral arterial and rectal temperatures.

However, there is one thing to consider, and that is that although the rectal temperature is above the temperature of the mixed blood, it may be a safety measure which we shall be glad to have, especially in high temperatures, where rectal temperatures of 104 and 107 are obtained. This may be a considerable safety mechanism.

It is difficult to explain the discrepancy between the rectal and the arterial temperature. There are several possibilities which may be considered. One is that the arterial and venous anastomoses around the rectum may give a true representation of the mean temperature of all parts of the body. For instance, although Dr. Eichna has not mentioned it, I know that he has some observations which indicate that the temperature of the blood from the liver is higher than some of these other temperatures; hence we may have in the rectum, really, a fine representation of mean body temperature, or we may not.

However, I think that some things he mentioned indicate to us, or at least to me, that we have to consider very carefully these temperature gradients in the vascular tree.

There have been observations made by Dr. Bassett and myself — this is the old story, that "I just happen to have a little slide in my pocket which I want to show you," but I don't — which indicate that the temperature of the peripheral blood is quite low. This may influence the general body temperature.

I believe that in the future any investigation of the effects of thermal agents on man must take into consideration the things which Dr. Eichna has so beautifully brought out today — that is, that one cannot depend on making the temperature measurement in any one part of the body and say that this is the answer. One has to know what happens in all parts, not just the muscles, not only the skin, not only the subcutaneous tissue, not only in the rectum, but all areas. One may consider the rectal temperature, but one must know what happens in all the vessels which either supply or which return blood from an area which is being treated.

Dr. Julia F. Herrick (Rochester, Minn.): For many years it has been of interest to physiologists to study the generation of heat, and some physiologists indicate that muscle is a factor in generating heat. Dr. Eichna's setup is very nice for studying just exactly that.

I would be very much interested in asking him whether stimulating the muscles of the leg would not raise the venous temperature above the arterial temperature, indicating that perhaps that is a source of heat.

I am sorry that I did not listen attentively enough to know his method of re-

cording rectal temperature. I was very much interested in the method of measuring intravascular temperatures. Did he have the same time response in measuring his rectal temperatures as he had in measuring his intravascular temperatures?

Dr. Eichna (closing): First, Dr. Herrick's questions. So much time has been taken up in trying to get the proper setup for determining the temperatures of various organs and vessels that we have only just begun to determine what happens under various types of changes in body economy which might change blood temperature. We have not as yet tried the effect of muscular stimulation or of muscular activity on blood temperature.

The rectal thermocouple was constructed of two wires, each gauge 30, which were protruding from the side of a plastic (Lucite) applicator. Therefore, the thermal junction itself was of small mass. The response times of all of the thermocouples were approximately the same, 95 per cent of full response in fifteen seconds. Perhaps the larger Lucite applicator may have changed temporarily the temperature of the rectal mucosa which the thermal junction was measuring, but certainly the junction itself, when dipped into something like water, gave a response time practically the same as that of the thermocouple stylets.

I wish at this time to point out that this study is a physiologic one. Its purpose is to give us a better idea of how the body responds to stresses. When we come to the practical application of these physiologic findings, we must use technics which are practical, and I should like to emphasize that, for practical purposes, the temperatures in the vein, in the artery and in the rectum were quite similar.

I should like at this time, too, to acknowledge Dr. Horvath's comments. We have had a long discussion on this topic. He has participated in some of our observations. Actually, this summer, he carried out some observations with us. He has contributed thermocouple wire; he has contributed polyvinyl plastic sheaths for me. He has been of great assistance to us.

PROGRESS REPORT

Physical Therapy, Past and Present

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Sydney, Australia

Physical medicine is both the oldest and the newest form of therapy. Tradition informs us that prehistoric man signified the selection of his future mate by hitting her over the head with a club and carrying her off to his cave. Even then, she was more fortunate than her modern sister, as she did have a home to be taken to, even if it was only a cave. When the bride elect had recovered from her pleasure and surprise at being so selected, she realized that she had a painful swelling on her scalp, and to ease the pain, she proceeded to rub this contusion, and thus laid the foundation for modern massage. The importance of water was also appreciated; not only was it used to sustain human life and promote growth of herbage, but after an injury the wound was bathed in a running stream. Modern hydrotherapy has evolved from this unpretentious start. The healing effect of the sun's rays was well appreciated by these prehistoric people. When they were ill, they lay in the sun to regain health. As man's intellect gradually developed, he realized more and more the importance of the sun. Without sunlight, grass and trees would not grow; seasons came and went at the behest of the sun.

Among prehistoric races, Sabeanism, or sun worship (the first great religion of the world), gradually developed. The early Egyptians built temples to Ra, the sun god. Aesculapius, the god of medicine, was the son of Phoebus Apollo, the sun god of the Greeks. Mithra (an Iranian god) was at the same time the sun god and the god of health. The mithraic cult spread over the whole of the then civilized world. Wotan-Odin was the god of healing of the ancient Germans, who used to expose their children on the housetops to "Wotan's eye." The Romans used solariums extensively for sun bathing.

Solariums during the last few years have been established in London to treat children from the slums (who see very little of the sun) with regular doses of ultraviolet radiation. During the war, ultraviolet clinics were established at coal mines where miners received regular doses of ultraviolet rays. A further clinic was established by the Navy at the Naval Dock at Portsmouth, at which all submarine crews were given general doses of ultraviolet radiation during their stay in port.

Isaac Newton, who lived only two hundred years ago, is recognized as a founder of modern light therapy. He split sunlight into its component parts by means

of a prism, proving that white light was composed of the seven colors of the spectrum.

In 1850 Sir Frederick Herschell discovered that there was an area below the red end of Newton's spectrum which caused higher temperatures in the thermometer than the visible red rays. From their position he called them infrared rays. The following year, John Ritter, a German physician, found there were also rays beyond the violet end of Newton's spectrum. These rays had the power of darkening silver chloride; thus were discovered the chemical rays now called ultraviolet rays.

Sir Humphrey Davy produced the first carbon arc ultraviolet lamp by connecting an electric circuit to two carbon pencils. Although he did not realize the richness of the ultraviolet radiation he produced, his work was followed by Nils Finsen, who installed the first light clinic in Copenhagen. Finsen is universally regarded as the founder of modern actinotherapy.

Much work has recently been done in the Scandinavian countries on the effects of different colors on the mental processes in health and disease. The Chinese centuries ago exposed sufferers from smallpox to red light, and this treatment was carried on into the last century. It has been reported that in a large photographic plate factory, the workmen in the red rooms were singularly lively, talking loudly and singing and arguing. When the red light was replaced by green, they became much quieter. It is also reported that if patients suffering from melancholia were placed in a red room for fifteen to twenty hours, they were more cheerful and developed an appetite for food. Yellow light is stated to increase the flow of gastric juice with increased hunger. Amber light gives a sensation of warmth, and amber glass is being used in the windows of halls, churches, et cetera. Green light has a depressing effect; although at first pleasant, it later becomes oppressive. Blue light has a strongly depressing effect. Jakesch emphasized the soporific effect of blue light and used blue chimneys on the lamps in his hospital wards at night.

Turning to the electrical side, it is noted that the first recorded case of electrical treatment is that of a soldier of the Roman emperor Tiberius, who trod on an electric fish and was thus "freed of the gout." Would that my patients were freed of the gout so easily!

Galen, of Pergamum, the founder of experimental physiology and surgeon to the gladiators, recommended repeated applications of the electric ray fish to the the head in cases of headache and neuralgia, thus giving the first shock treatment in mental disease. Although the ancients knew of the magnetic properties of amber and sulfur, it was not until the advent of William Gilbert in Queen Elizabeth's reign that any real advance was made in electricity. In the year 1600, he published in London his epoch-making treatise on magnetism. Unfortunately, Gilbert's work was not understood, and for years, except by a few scientists, was practically ignored in England.

Benjamin Franklin introduced the terms "positive" and "negative" in reference to electricity and used discharges from the leyden jar in the treatment of disease. Luigi Galvani was professor of anatomy at Bologna University in 1786. When dissecting a frog in close proximity to a charged electrical machine, he noted that when the scalpel touched the frog's muscles they contracted violently. Alexandro Volta continued Galvani's experiments and proved that a current of electricity could be produced by the contact of two metals, one with another, in an acid bath, and that this current was the cause of the muscular contraction. Volta devised the first voltaic pile for the production of the constant current. Michael Faraday followed his work by experimenting with electromagnetic induction. Guillaume Duchenne followed Faraday's work and discovered that by connecting moistened sponges placed on the skin to wires from a faradic battery, he could produce muscular contractions. In England the first hospital in which an electrical machine was used clinically was the Middlesex Hospital, in 1767. Dr. Golding Bird established the first department of electrotherapy in Guy's Hospital in 1814. Time does not allow mention of a host of other workers during the twentieth century who further developed galvanism, faradism, long wave diathermy and short wave diathermy. Schliephake, of Jena University, first used short wave diathermy on a patient in 1928.

It is a sorry commentary on modern civilization to have to admit that it takes war to stimulate medical research and discoveries. This is definitely true of physical medicine. World War I gave the first great stimulus to this work in the British Empire.

The Council on Physical Medicine of the American Medical Association has been active for some years, but physical medicine was given a tremendous stimulus by the appointment of the Baruch Committee in 1944. This committee came into being as the result of a generous gift from Mr. Baruch and is composed of a number of distinguished clinicians and educators who

(*Continued on page 598*)

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.·. EDITORIALS .·.

ELECTROMYOGRAPHY IN PHYSICAL MEDICINE

Coincident with the recent rapid growth in the field of physical medicine and rehabilitation have been the developments in the field of electronics. In the past electromyography has largely been confined to studies in the physiologic laboratory, although a few outstanding neurologists have made clinical studies of various neuromuscular abnormalities. Of particular note have been the reports of Denny-Brown and Pennybacker[1] on muscular fasciculations and fibrillations, and other studies on spasticities and involuntary movements by Hoefer and Putnam.[2-4]

The establishment of the American Board of Physical Medicine and Rehabilitation has emphasized the importance of a thorough knowledge of basic and clinical research, particularly in the field of neurophysiology. It is natural, then, that the training of future physiatrists should include the study of electromyography. An understanding of the electrical engineering factors is essential to insure that in clinical practice proper selection of amplifying and recording instruments is made, together with the choice of proper electrode technic. Some of the important considerations in this direction have been previously described in some detail by Schwartz et al.[5] and Huddleston and Golseth[6] and others.[7-9] The final answer for the optimum technic for the study of various clinical conditions still remains unsettled. It appears that for recording of the minute and brief potentials given off from fibrillating denervated muscles, intramuscular electrodes are indicated and recording systems capable of following with high fidelity rapid frequencies, with minute duration impulses of very low voltage such as is possible with the cathode ray oscilloscope or similar optical recording systems. Surface electrode technics with the slow ink-writing recording systems appear, however, to have a definite advantage in clinical electromyography. They are more easily applied, particularly for multiple channel recording, and the possibility of injury artefacts from the intramuscular needles is eliminated. This method may be used to advantage in the study of tremors and other involuntary muscular movements as described in the excellent article of Clare and Bishop[10] in the present

1. Denny-Brown, D., and Pennybacker, J. B.: Fibrillation and Fasciculation in Voluntary Muscle, Brain **61**:331 (Sept.) 1938.
2. Hoefer, P. F. A., and Putnam, T. J.: Action Potentials in Muscles in Normal Subjects, Arch. Neurol. & Psychiat. **46**:201 (Aug.) 1939.
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9. Seyffarth, H.: The Behaviour of Motor Units in Healthy and Paretic Muscles in Man, Acta Psychiat. et Neurol. **16**:79, 1941.
10. Clare, M. H., and Bishop, G. H.: Electromyographic Analysis of the Physiologic Components of Tremor, Arch. Phys. Med. **30**:559 (Sept.) 1949.

issue of the ARCHIVES. This method has also been used for the quantitative analysis of muscle spasm in various conditions of hypertonicity as in hemiplegia, cerebral palsy,[11] and the "spasm" of poliomyelitis.[12]

When all the problems of the technic of electromyography are solved there remains, however, the most important element, that of interpretation. This fact is emphasized in the recent paper of Golseth and Huddleston[13] concerning the diagnosis of lower motor neuron disease. The interpretation of neuromuscular disorders based on lesions at a higher level in the central nervous system such as those of the basal ganglia, cerebellum or cortex, calls for even more careful simultaneous clinical neurological observation. Electrical phenomena recorded from peripheral musculature must be correlated with the factors of positioning, degree of relaxation, comfort of the patient, and cooperation, so as to eliminate voluntary tensing and other motor reactions. The possibility of reproducing apparently abnormal electromyographic records as indicated by Clare and Bishop[10] is a valuable contribution, and their results should be carefully studied by all those attempting research in the field of electromyography. They have justly pointed out the difficulty in deciding the difference between what is normal and abnormal in the electromyogram. Recording and interpretation is not yet standardized as in the case of electrocardiograms, and the physiatrist must incorporate a careful clinical examination of the state of muscles during the recording, must utilize tests; movements and postures, or occasionally use drugs of known reaction on the neuromuscular system in order to interpret the complicated reflex activities of the central nervous system on the basis of a few electrical discharges from the distant peripheral musculature. It is hoped that the more and more frequent papers on electromyography appearing in the ARCHIVES and other current medical publications will serve as a stimulus for further investigation in this field so that electromyography may assume its correct role among the electrodiagnostic measures of physical medicine and as a reliable research method of instrumentation.

11. Berger, F. M., and Schwartz, R. P.: Oral "Myanesin" in Treatment of Spastic and Hyperkinetic Disorders, J. A. M. A. **137**:772 (June) 1948.
12. Watkins, A. L., and Brazier, M. A. B.: Observations on Muscle Spasm in Poliomyelitis: Electromyographic Studies on the Effect of Various Forms of Thermal Therapy and of Prostigmine, Arch. Phys. Med. **26**:325, 1945.
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A NEW PHYSICAL TREATMENT FOR THE PAIN OF AMPUTEES

One of the most discouraging aspects in the treatment of patients with amputations of the extremities is that of painful neuromata and phantom limb pain. There still remains with us in hospitals, rest homes, and upset families the occasional patient who suffers persistent pain of this sort for year on end. Surgical procedures for relief of such pain unfortunately have proven of no certain benefit. All too often re-amputation has been tried and failed. Tractotomy and frontal lobotomy have even been resorted to, but again have not given us the solution to this problem. Although it seems likely that the incidence of incapacitating pain in amputees has been greatly reduced by modern surgical technics combined with antibiotics, there still are enough patients to make of practical importance a new and simple method of treatment recently reported from England.

Russell's[1] preliminary paper recording apparently successful treatment by repeated percussion to stump neuromata should interest all those in the field of physical medicine and rehabilitation. He has reported seven cases, three of which

1. Russell, W. R.: Painful Amputation Stumps and Phantom Limbs, Brit. Med. J. **1**:1024 (June 11) 1949.

were above-knee amputees dating back to the first World War, the others being of more recent origin including upper extremity cases. In brief, his method of treatment consists in application of local pressure directly over trigger spots of pain in relation to neuromata which had formed over the cut end of the nerve. Experiments revealed that local novocaine injection was not needed. Instead, a sphygmometer cuff was applied to the stump at a pressure of 200 mm. Hg. for 2-3 minutes to lessen sensitivity. A wooden applicator with a smooth metal cap was improvised and applied directly over the neuroma. This was hammered for approximately ten minutes twice daily to begin with and later less frequently. It was noted that painful sensations were at first produced, then diminished, and at the end of treatment pain disappeared. The patients were then advised to apply their prosthesis and immediately exercise. The patients themselves were quick to realize the beneficial effects of this therapy and determined the optimum period of percussion. They continued to treat themselves independently for several weeks or months as needed. Examination[2] of some of these patients has proven to be even more convincing as to effectiveness than the report published in the *British Medical Journal*. The physiologic mechanism responsible for these results is open to query. A possible explanation is that some area in the central nervous system which normally is constantly receiving afferent impulses from an intact limb, when deprived of such stimulation in some way produces phantom limb and other unpleasant sensations. The bombardment produced by this percussion therapy may supply the necessary sensory stimulation and reestablish normal sensory pathways. This simple physical method of treatment is worthy of further trial and investigation by physiatrists presented with the problem of the rehabilitation of the amputee.

2. Viets, H. R.: Personal communication.

GUSTAVUS M. BLECH, M.D.

Dr. Gustavus M. Blech, a well known physician of Chicago who had retired with the rank of colonel in the Medical Corps of the United States Army, died at his home on Aug. 10, 1949. He was 78 years of age. Soon after his graduation he volunteered for service in the Spanish-American war and later served as an observer for the American Red Cross in the Russo-Japanese war. As a member of the Illinois National Guard, he organized the first Illinois field hospital and served with it on the Mexican border. He went overseas in 1917 as the assistant division surgeon of the 33rd division and later was in charge of base hospital 208 at Bordeaux, France. Dr. Blech was co-author with Cornell C. Lynch, former Surgeon of the Army, of "Medical Tactics and Logistics." Because of meritorious services in the field of physical medicine, he was awarded the Gold Key by the Congress in 1935.

Progress Report
(*Continued from page 594*)

survey the field and direct research into physical medicine.

The Council on Physical Medicine of the American Medical Association, as well as directing research, through the Baruch Committee, has a technical advisory board which examines all new equipment produced by manufacturers. If equipment is not up to standard requirements, either in construction or in performance, it is not passed. If up to standard, it is stamped with the approval of the committee for clinical use. Such a committee with similar power, is greatly to be desired, both here and in England.

On Oct. 20, 1943, the British Association of Physical Medicine, under the presidency of Lord Horder, came into being. Regular meetings are held with an interchange of speakers and papers with the sister association in America. Conferences between the British Association of Physical Medicine and the councils of the Colleges of Physicians and Surgeons resulted in 1945 in the establishment of a diploma of physical medicine of the combined College of Physicians and Surgeons in England. This is a two year diploma course, held principally at Guy's Hospital and is comparable to the fellowship diploma in surgery and the membership diploma in medicine.

With the approval and blessing of the British Association of Physical Medicine and the Federal Council of the British Medical Association in Australia, an Australian section of Physical Medicine within the British Medical Association was formed in Australia in 1945, with Dr. F. May, of Melbourne, as our first President and I as Secretary. The objects of the Association as set out in the constitution are:

1. To encourage the study of the action of physical agents and their application in the prevention and treatment of illness and injury, and in the restoration of function.
2. To encourage within the medical profession, undergraduate and postgraduate training in the principals and practice of physical medicine.
3. To provide opportunity for members to discuss matters appertaining to physical medicine.
4. To evaluate apparatus and methods claimed to be of use in physical medicine.

It is greatly to be deplored that there is not yet in the University of Sydney any undergraduate instruction in physical medicine. The ignorance of the young graduates in completing the year's residence in a hospital, as far as physical medicine is concerned, is profound. All they know is that there is a department somewhere in the bowels of the hospital (which few, if any, have ever seen) to which patients with chronic and troublesome arthritic conditions may be sent by the clinician with the fervent hope that he will not see them again. The physical therapy department in many of our hospitals has gradually developed in conjunction with the orthopedic departments and is under control of the orthopedic surgeons. This arrangement is undoubtedly very convenient for the orthopedic surgeon, but the result is that the physical therapy work done is almost wholly orthopedic in nature, to the exclusion of such valuable treatment for other conditions which is not available for general patients.

One of the objects of our association is that all physical therapy departments should have a man trained in physical medicine in charge of the department; then all types of patients needing physical therapy may be treated.

The postgraduate committee in medicine has included some instruction in physical therapy in its courses. As a result, the general practitioner is gaining increased knowledge of the type of physical therapy which will be of benefit to his patients.

An arthritis clinic for the investigation of all arthritic patients has been established this year at the Royal Prince Alfred Hospital. The personnel of this clinic consists of a physician, a specialist in physical medicine and an orthopedic surgeon. These men, in conjunction, see all arthritic patients referred to the clinic from the outpatient department of the hospital and make a full investigation. As the clinic is part of the hospital, full pathologic, biochemical and radiologic investigation can be made. In addition, there are available the physical and occupational therapy departments. When this clinic is in full swing, much useful information on arthritis in Australia will be collected.

In 1946 a Physiotherapy Registration Act was passed in New South Wales. This Act required all persons practicing physical therapy to be registered. Since November, 1947, no person may be registered who has not passed the prescribed course of training and examinations.

The demand by the general public for physical therapy treatment is shown by the fact that over seven hundred applications for registration have been examined

by the board. The type and knowledge of many of the applicants has shown that this Act was long overdue, but a further tightening of the regulation is required. At the present time, any unqualified person can purchase any equipment and, provided he does not use the name "physiotherapist," can practice under the guise of naturopath, osteopath, nature healer, health and beauty culture, and what have you. It is hoped that in the near future an amendment to the Act will prevent the public from being exploited by unscrupulous charlatans.

CORRESPONDENCE

Is There Merit in the So-Called "Cerebral Palsy" Program? *

To the Editor:—Spastic paralysis and allied disorders of the central nervous system which must be considered in differential diagnosis have recently been widely publicized under the all-inclusive title of "cerebral palsy." An attempt is being made to establish expensive and elaborate training programs for the care of these patients in many of our crippled children's clinics. In some instances writers imply that such a program of muscle training and reeducation will afford continuous improvement in muscle control and function and will eliminate need for surgery to correct deformities even in selected cases. What can be expected from a program of this type?

My opinions are based on experience derived from study of a group of 2,096 consecutive cases seen prior to 1948 at the St. Louis Unit of the Shriners' Hospital for Crippled Children. These allied disorders of the central nervous system can be adequately classified under the four major headings shown in the table, which also shows the relative frequency with which each has been encountered. The classification into which each case falls is dependent on the clinical observations and manifestations, and these in turn are dependent on the portion of the central nervous system involved. The classification indicates that an all-inclusive term such as "cerebral palsy" is inadequate and nondescriptive. The use of a term of this type is comparable to the use of the term "rheumatism" in describing the various types of arthritis. Better would be a simple classification by which each case would be identified accurately according to the type of involvement.

The patients with a picture of spastic paralysis resulting from a pyramidal tract lesion comprise a large percentage of the total. This involvement may represent a simple uncomplicated spastic paralysis, but in many instances it is complicated by other clinical manifestations which are indicative of involvement of portions of the central nervous system other than the motor pathways. These manifestations are impaired sense of balance, impaired mentality, impaired speech, associated congenital athetosis or even associated epilepsy. These manifestations are of great clinical significance. The group with true spastic paralysis is the only one of the four in which surgical correction of deformities can be considered. Yet, for a patient to be suitable for surgery, there must be a satisfactory sense of balance and little or no associated athetosis. Speech and mentality should also be satisfactory if the child is eventually to become independent and self supporting. In this total series of 2,096 cases, of which 1,459 showed involvement of the pyramidal tract, only 546 patients could be considered suitable for surgical correction of the deformities which were present.

From a purely practical standpoint, all patients may be grouped under one of three headings: 1. Those in whom the involvement is mild, who do not require treatment and can be expected to take a normal place in society, remaining independent and self supporting. Approximately 25 per cent of the entire group can be so classified. 2. Those with moderate involvement and for whom much can be accomplished by reconstructive measures. This group also comprises about 25 per cent of the total number. 3. That large number of persons who show extensive involvement, from pyramidal tract lesions, extrapyramidal lesions, impaired mentality, cerebellar lesions or those with decided spasticity complicated by other associated conditions. These patients represent a type of involvement for which surgical reconstructive measures offer no hope of benefit, and little or nothing can be accomplished from any form of treatment. This large third group comprises about 50 per cent of the total number of cases.

Much has been written and said in recent years about the value of an elaborate training program for the management of these cases. In some instances elaborate institutions are being established for the care of the children to extend over a period of many years in order to furnish them with adequate supervised training and physical therapy.

* Rep. with permission, J. A. M. A. **140**:1231 (Aug. 13) 1949.

For the wealthy such a program is of course acceptable, not from the point of view of treatment and any benefit derived, but from the point of view of care which they can well afford. These institutions often attempt to establish as nearly as possible surroundings and facilities which are within the realm of the patient's physical abilities or, in brief, a country club for "spastics." Even some of the state crippled children's services have attempted to follow this pattern and establish facilities for the management of all cases of spastic

Disorders of the Nervous System Observed at Shriners' Hospital, St. Louis.

Type of Involvement	No. of Cases
Pyramidal tract lesions	1,459
Extrapyramidal lesions	320
Impaired mentality	289
True cerebellar lesions	28
Total	2,096

paralysis or allied disorders of the central nervous system. Some spontaneous improvement invariably occurs in these patients and can be expected to continue through their adolescent years. This depends primarily on the normal development which takes place in the central nervous system. Much of the improvement which is credited to these specialized training programs may well be due to nothing more than the normal developmental processes which continue without regard to the treatment. The final picture in these patients as regards mentality, speech, sense of balance and the function of their involved extremities depends more on their normal developmental processes than on any combination of outside factors.

The large third group, representing those with extreme involvement, offers a fertile field for the proponents of any program of training and muscle reeducation. This may be attributed partly to the fact that it is difficult or impossible to evaluate accurately the results obtained and still more difficult to know where credit for any improvement should be placed. The eternal cycle of changing therapeutic measures in those crippled children's problems which result from disease of the central nervous system is sufficient proof that we are clinicians, and orthopedists have more difficulty with these problems than with any other. We are impressionable and often influenced by suggestions which cannot be justified on the basis of the pathologic condition involved. The patient in this third group represents an extreme involvement of the central nervous system and in some instances an extreme developmental defect, which cannot be replaced or corrected under present medical accomplishments. Any program of muscle training and reeducation is merely tinkering with the peripheral, secondary manifestations and cannot be expected to alter the primary pathologic change. These patients may show some improvement in subsequent years, but this improvement will occur spontaneously from natural development.

Since so little can be accomplished by expensive and extensive training programs in the third group with extreme involvement, and since the first two groups do not need it, it seems unwise for any crippled children's organization to expend the vast sums of money which would be required to establish such a program. What is actually needed for this group of patients is the establishment of institutions where the everyday needs of the patient could be adequately met without any attempt at expensive training and rehabilitation. Our present institutions for the mentally incurable, representing principally the state asylums for the mentally disturbed, are not satisfactory for this type of patient and are so overcrowded that it is impossible to admit a patient even when the family consents. Institutions could be established which would give the care required by these patients without entailing a tremendous expense or large personnel. The patients themselves would be happier, since they would be in an environment which they would consider more normal with the type of involvement which they show and since they would be relieved of the strain resulting from their contact with the fast pace of everyday life. More than this, one of the greatest advantages resulting from adequate institutions of this type would be derived by the normal members of the family who remain at home. Any home with a child of this type seldom enjoys a normal home life. The patient often requires all of the time and care which the parents can give, frequently resulting in the neglect of the normal children who could hope to derive benefit from their guidance and counsel. It would seem wise therefore to discourage serious consideration of recent proposals calling for the establishment of elaborate and expensive training programs by the various state crippled children's services and other charity organizations. Efforts should be made instead to obtain establishment of institutions in which adequate everyday care could be given to patients who fall in the unfortunate third group.

H. R. McCARROLL, M.D.,
St. Louis.

This letter was referred to Drs. Perlstein and Phelps, who reply:

To the Editor:—Some of the arguments set forth by Dr. McCarroll are logical, but would have more merit if his premises were as correct as his thinking. He states, for example, "In some instances writers imply that a program of muscle training and reeducation will afford continuous improvement in muscle control and function and will eliminate need for surgery to correct deformities even in selected cases. What can be expected of a program of this type?" The implication is, of course, that this quotation expresses the opinion of those who are most interested in furthering the "so-called cerebral palsy program." In actuality, however, nothing could be further from the truth.

Any program which limits itself to muscle training and reeducation or to surgical correction and ignores socialization, speech correction, education,

occupational therapy and the correction of sensory, emotional and other defects is incomplete. Despite Dr. McCarroll's statement as quoted here, I do not believe it possible to find anyone experienced in the field of cerebral palsy who would say that surgery should never be performed in any case. I think that the opinion would be almost universal, however, that there has been too much surgical treatment in the past.

The extent of Dr. McCarroll's experience in cerebral palsy is evidenced by his statistics. These same statistics, however, indicate that his experience has been of a rather restricted nature. His incidence of cases with pyramidal tract lesions is over four times that of cases with extrapyramidal lesions, as would be expected in an orthopedic hospital where the surgical aspects of the problem receive the main emphasis. It is well recognized that deformities and muscle imbalances due to pyramidal tract lesions are more amenable to surgical correction than those due to extrapyramidal involvement. Similarly, convulsive seizures and defects in mentality are much more common with pyramidal tract lesions (with the exception of paraplegic cases) than with extrapyramidal involvement. However, in training centers or schools for the mentally educable cerebral palsied, at least 50 per cent of the children have extrapyramidal tract lesions, as they and the spastic paraplegic patients constitute the bulk of the educable cases.

Many of the children originally seen in screening neuropediatric clinics never get to orthopedic hospitals (1) because their physical involvement is so minimal that treatment is not indicated; (2) because many die or are institutionalized during the first few years of life, or (3) because many of the lesions are of the extrapyramidal type and not generally amenable to surgical correction.

The material, therefore, on which Dr. McCarroll bases his conclusions is not representative of the cerebral palsied children seen in a general pediatric or neuropediatric clinic.

The question arises as to whether the teaching of such persons is worth while in time, effort and money. It may be advantageous to teach even the patient who is severely handicapped mentally some degree of self help or locomotion, even though it may be necessary eventually to place him in an institution for the feebleminded. Not only does such a patient have a richer, more satisfying life, but the cost of his care is substantially reduced.

Although Dr. McCarroll decries the establishing of institutions which could be called "country clubs for spastics," he, himself, suggests that there is a need for custodial care institutions with as normal an environment as possible. I agree with both of his statements. Institutional care, in its simplest form, is expensive, nor is it desirable to place in custodial care any person who may be trained so that he may live satisfactorily outside an institution. The cost of rehabilitation of such a person and the cost of the family in terms of social and economic disability caused by having such a person at home must also be taken into consideration. Any service, however, which can to some appreciable degree rehabilitate such a handicapped person is worth considerable expense.

Dr. McCarroll points out that many children will improve without having any type of treatment. This is, of course, well known, and no honest doctor would fail to credit the natural developmental urges in children for their full share in rehabilitation. As a matter of fact, one should always take advantage of this phenomenon and therefore attempt to stimulate this inherent tendency to improve by an approach to the emotional as well as the physical disabilities that exist in the child.

The ineffectiveness of such service comes, first, from failing to take the complete point of view of the person as an individual and considering him only as one who has difficulties in speech or one who has only deformities of body or one who has only emotional or mental problems. As no single specialist can be qualified to treat all facets of the disease, a program must include a complete list of all the medical, psychologic and social services which are available in the community. To consider the surgical approach as the most important is just as fallacious as considering drug therapy the most important solution.

Second, one must not consider cerebral palsy as an isolated problem but as part of the whole problem of the handicapped child. The reason for the present emphasis on cerebral palsy is that this group represents the largest segment of forgotten or neglected handicapped children. The National Foundation for Infantile Paralysis has been able to supply funds for the other large groups of crippled persons. The National Society for Crippled Children, in its promotion of the cerebral palsy campaign, has stressed that its interest is providing service for the cerebral palsied as a part of the total program for the handicapped.

Third, the cerebral palsy program has been damaged and to a certain amount retarded by well meaning lay organizations which have attempted to set up programs without medical help. By the same token, it has been harmed by doctors who have specialties in a single field who have not sought the help of their fellow specialists in other fields as well as of social service workers and psychologists. A clarification of the problem is being sought by a group of doctors of many specialties who have banded together in the American Academy of Cerebral Palsy, where points of view on all aspects of the problem can be freely exchanged. It is the opinion of groups like this that a properly constructed and properly administered cerebral palsy program effectively gains for society more than it spends.

M. A. PERLSTEIN, M.D.,
4743 N. Drake Ave., Chicago 25.

To the Editor:—I question some of Dr. McCarroll's statements. For example, the statement, "Much of the improvement which is credited to

these specialized training programs may well be due to nothing more than the normal developmental processes which continue without regard to the treatment" and the following sentence are both unfounded statements of his opinion. Those who have worked with these specialized institutions over a period of years develop a different opinion in comparing cases treated by this method with cases not so treated.

The Shriners' hospitals do not have long time care as is well known; therefore patients cannot be followed in such a situation long enough to determine what the effects would be.

The conclusions in his last paragraph are based on his previous statements, of which he has no actual proof. He states, "Since so little can be accomplished by expensive and extensive training programs . . . etc." I think the fact that many states are undertaking to set up training programs for these patients and that most of this has been the result of observation by many of us in itself would indicate the value of such programs.

The cerebral palsied children who used to be brought to me five or six years ago had an average age of 6 or 7 years. At this age, I found many deformities due to postural conditions and in walking, such as contractures of the knees, tight heel cords, scoliosis, wrist drop and contracted hands.

Now that cerebral palsy has become so much better recognized, my average new patient age is between 1 and 2 years. I have found that, in most cases, by appropriate apparatus and training, most of the deformities seen in these older children previously untreated can be entirely prevented. This, I think, is an important phase of the picture.

There are adults that I have seen, previously untreated, in whom the lack of locomotion or use of the arms is entirely due to the deformities, and these persons could be useful and self sufficient had the deformity element been prevented in their early childhood.

In any plan it is well to present both sides of the picture, and on this basis I think that we should give some consideration to Dr. McCarroll's statements. However, I feel certain that the value of such programs has been definitely established and that in many instances the expense of setting them up does not need to be as great as he points out.

WINTHROP M. PHELPS, M.D.,
Baltimore.

MEDICAL NEWS

Dr. Coulter Appointed Chairman

Dr. John S. Coulter has been appointed as chairman of the Committee on Physical Therapy of the Illinois State Medical Society for the year 1949-1950. Other members of the committee are Drs. Emil D. W. Hauser, H. Worley Kendell and Disraeli W. Kobak of Chicago; Dr. Hugo Cooper, Peoria, and Dr. Ralph P. Peairs, Normal, Ill.

Colonel Smith Appointed

Colonel Emmett M. Smith has been appointed chief of the Physical Medicine Consultants Division in the Surgeon General's Office.

Baruch Fellowships in Physical Medicine

The Baruch Committee on Physical Medicine announces that it is offering a limited number of fellowships in Physical Medicine.

The purpose of these fellowships is to provide, at Medical Schools acceptable to the committee, training for one year in laboratory and clinical subjects in the field of Physical Medicine.

Applicants must have an M.D. degree from an approved medical school and a minimum of one year of internship in an approved hospital.

The stipend will be $2500 for single persons and $3000 for married persons.

Applications may be obtained from the Baruch Committee on Physical Medicine, 30 North Michigan Avenue, Chicago 2, Illinois.

Council Approves Courses for Training in Physical Therapy

The Council on Medical Education and Hospitals of the American Medical Association announces the approval of three courses for training in physical therapy. They are Cleveland Clinic Foundation, Army Medical Department and Permanente Hospital.

Dr. Allen Takes Oath as Division Chief

Dr. Raymond B. Allen was sworn in July 6 by Secretary of Defense Louis Johnson as Director of the newly formed Medical Services Division of the National Military Establishment. Dr. Allen, who is President of the University of Washington, Seattle, will remain as Director of Medical Services for three months, returning to the University of Washington on October 1.

Dr. Lull Awarded Legion of Honor Medal

His activities on behalf of the French people immediately after World War II have won for General George F. Lull, former Deputy Surgeon General of the United States Army and now Secretary and General Manager of the American Medical Association, the coveted Legion of Honor medal from the French government. Formal presentation of the medal was made by Jean Joseph Viala, French Consul General, in Chicago, Wednesday, July 27.

His appointment as Deputy Surgeon General of the United States Army in 1943 climaxed a career in Army medicine started in 1912, during which he served in all grades from lieutenant to major general. He was awarded the Distinguished Service Medal for his activities in World War II.

Dr. Osborne Assigned

Dr. S. L. Osborne has been assigned by the Department of Public Welfare of the State of Illinois to inspect the State institutions for mental care. Dr. Osborne is currently conducting lectures at the various institutions on hydrotherapy and at the same time making recommendations for establishment or improvement of departments of physical medicine.

Ohio Society for Crippled Children, Inc.

The 30th Annual Meeting of The Ohio Society for Crippled Children will be held October 16-17 at the Deshler-Wallick Hotel, Columbus, according to an announcement by James A. Hewitt, president.

National and state authorities on various phases of physical handicap will take part in the two-day program.

Annual Meeting National Society for Crippled Children and Adults

The annual convention of the National Society for Crippled Children and Adults will be held Nov. 7, 8 and 9, 1949, at the Hotel Commodore in New York City.

Special Training Course

To help meet the employment problems of the cerebral palsied and other severely handicapped, a special training course for employment and placement counselors will be held Nov. 7 to Dec. 7, 1949, in New York under the joint sponsorship of Alpha Gamma Delta, international women's fraternity and the National Society for Crippled Children and Adults.

Graduation at Columbia

Appropriate exercises marked the graduation, August 12, of the present class of students trained in physical therapy, at Columbia University, College of Physicians and Surgeons.

New Appointments

Dr. James F. Bosma, Minneapolis, assistant professor of pediatrics at University of Minnesota and Dr. Donald R. Lannin, St. Paul, in charge of orthopedics at University of Minnesota Health Service, have become associated with the medical staff of Elizabeth Kenny Institute in Minneapolis.

Other members of the Institute's medical staff are: Dr. Miland E. Knapp, chief of physical medicine in charge of treatment and training; Dr. Myron Lecklitner, Dr. Theresa Haddy and Dr. R. E. Worden, associates in physical medicine; Dr. S. R. Seljeskog, chief of internal medicine and contagion; Dr. Lewis Sher, in charge of outpatient department and Dr. Wallace Cole and Dr. John F. Pohl, consulting orthopedists.

Army Medical Department Sends Consultants to Far East

A team of consultants, including three civilians and one Army physician, left Washington for a 35-day trip to the Far East Command under the Army's Civilian Consultants Program.

Representing the Army is Colonel Warner F. Bowers, Chief, Surgical Consultants Division, Surgeon General's Office. The civilian consultants are Dr. Henry H. Kessler (Orthopedics) of Newark, N. J.; Dr. Bruce Webster (Internal Medicine), New York, N. Y., and Dr. Russell N. DeJong (Neuropsychiatry), Ann Arbor, Michigan.

To Study Rheumatic Diseases

An advisory group of nationally known physicians and medical scientists, has been appointed to find practical ways for combatting rheumatic diseases, by Federal Security Administrator Oscar R. Ewing.

The group will be headed by Doctor Phillip Hench of the Mayo Clinic, Rochester, Minnesota. One of the functions of the study section will be to explore the recently discovered possibilities of two substances, cortisone, popularly known as Compound E, and ACTH (adrenocorticotrophic hormone), which have displayed remarkable, though temporary, power to alleviate symptoms of patients suffering from rheumatoid arthritis, according to Surgeon General Leonard A. Scheele of the Public Health Service, who appointed the group.

Doctor Hench and Doctor E. C. Kendall headed a Mayo Clinic group which first investigated the two compounds. Their findings were made known several weeks ago.

Ten prominent investigators in all have accepted appointment to the new advisory body, which will be known as the Arthritis and Rheumatism Study Section of the National Institutes of Health. Seventeen other study sections advise on various diseases and basic medical research. In addition to Dr. Hench, members of the new group appointed are: Dr. Walter Bauer of Boston, Massachusetts, Massachusetts General Hospital; Dr. Granville Bennett of Chicago, Illinois, University of Illinois

School of Medicine; Dr. Jerome W. Conn of Ann Arbor, Michigan, University of Michigan; Dr. W. Paul Holbrook, Tucson, Arizona; Dr. Robert Loeb of New York, New York, College of Physicians and Surgeons; Dr. Fred Moore of Los Angeles, California, University of Southern California School of Medicine; Dr. Jane A. Russell of New Haven, Connecticut, Yale University School of Medicine; Dr. Emil L. Smith of Salt Lake City, Utah, University of Utah School of Medicine, and Dr. Alfred L. Wilds of Madison, Wisconsin, Professor of Chemistry, University of Wisconsin.

The study section will advise the Public Health Service on development of a program to combat these diseases and on grants of Federal funds to aid rheumatic disease research in hospitals and medical schools and other non-Federal institutions throughout the country.

In addition to research in treatment, extensive investigation will also be directed toward discovery of the basic causes of various forms of rheumatism and allied conditions, and determining the precise method of action of the new compounds and their subsidiary effects on the human body.

A parallel effort will be necessary in order to discover modified or new methods of producing the compounds. Both substances are now obtained in microscopic amounts from animal sources by complex and costly processes. The amount obtainable by present methods is so small that it is inadequate for research purposes and insufficient to treat more than a handful of the nation's arthritis victims.

Research on Asthma

A grant of $36,861 to permit studies of the nerve supply of the human lung has been made to the department of surgery of George Washington University Medical School by the Veterans Administration. The grant will provide funds for studies with particular reference to the surgical treatment of asthma. Studies will be continued over a two year period.

"Polio" 1949

Weekly reports from the United States Public Health Service indicate 3,197 cases of infantile paralysis from January 1 through July 2, 1949. The American Physical Therapy Association in cooperation with the National Foundation for Infantile Paralysis is recruiting physical therapists to work from three to six months in epidemic areas. If any physical therapist who is a graduate of an approved school or a senior registrant of the American Registry of Physical Therapy Technicians or a member of the American Physical Therapy Association is available for such an assignment he should phone New York, JUdson 6-2932 collect. Details in regard to these positions may be secured from "Polio" Recruitment Service, American Physical Therapy Association, 1790 Broadway, New York City. Physical therapists who are not permanently employed should give particular consideration to accepting at least a three months assignment to contribute to this much needed care.

The Kappa Delta Award for Research in Orthopaedic Surgery

The National Council of the Kappa Delta Sorority has inauguated a prize of one thousand dollars to be given annually by the American Academy of Orthopaedic Surgeons for the best research in orthopaedic surgery performed during the year by an individual in the United States. The first award, for the year 1949, will be announced at the seventeenth annual convention of the Academy in New York, February 11th, 1950. Those wishing to compete for this prize can secure further information from Dr. Walter Stuck, 1426 Nix Professional Building, San Antonio, Texas, Chairman of the Award Committee for 1949.

Physical Rehabilitation Televised Over WGN-TV

"Building A New Life" was the title of a telecast over WGN-TV, Wednesday, September 14. Participants were Dr. Kelso Carroll, Manager, Veterans Administration, and Dr. Louis B. Newman, Chief, Physical Medicine and Rehabilitation Services at the Administration, both of Hines, Illinois. Telling their own story in rehabilitation were two paraplegias as they demonstrated basic procedures in learning to walk, to use manual appliances and to gain occupational independence through vocational guidance.

This program ably demonstrated the success of television as an important medium for health education. Combining the seeing and hearing factors, the telecast featured professional persons and their patients as they worked to build a new life.

This telecast on physical rehabilitation was one in a weekly series on health education developed by the Educational Committee of the Illinois State Medical Society, of which Dr. Charles P. Blair, Monmouth, Ill., is Chairman and Dr. Ford K. Hick, Chicago, Vice Chairman. The series which is now in its ninth month is provided as a public information service in cooperation with WGN-TV.

Institute for Muscle Research

A group of scientists headed by Dr. A. Szent-Gyorgyi, Bethesda, Md., is organizing an Institute for Muscle Research. The institute has a laboratory at the Marine Biological Laboratory at Woods Hole, where seven researchers are working. Another group is conducting research at the National Institute of Health, Bethesda, Md. The research outside this institute is financed by the Muscle Institute, which attempts to collect funds and has received $25,000 from the American Heart Association. The institute was founded with the aim to provide means necessary for the continuation of Dr. Szent-Gyorgyi's research in the United States.

BOOK REVIEWS

RADIOACTIVE INDICATORS, THEIR APPLICATION IN BIOCHEMISTRY, ANIMAL PHYSIOLOGY, AND PATHOLOGY. By *George Hevesy*, Institute for Research in Organic Chemistry, University of Stockholm, Sweden; Institute for Theoretical Physics, University of Copenhagen, Denmark. Cloth. Pp. 556. Price, $10.00. Interscience Publishers, Inc., 214 4th Ave., New York 3. (Published in cooperation with Nordeman), 1948.

Few books have been written to date on radioactive isotopes in relation to their application of biochemistry, animal physiology, and pathology. This volume, written by a Nobel Prize winner, is an excellent compilation of the pertinent facts known as of today.

There are twelve chapters dealing with many subjects; a few of them are, production of radioactive indicators, radioactive isotopes of possible interest in tracer work, determination of radioactivity, absorption, distribution, excretion of elements and application of isotopic indicators in the study of permeability of phase boundaries.

An important accessory to the book is the Segrè chart, which may be found in a pocket attached to the back cover. This chart orients all of the stable and radioactive isotopes with respect to one another.

This book is a valuable contribution to the workers in the field of the medical aspects of atomic energy. It is not likely to be used extensively by the general practitioner.

DOCTORS OF INFAMY: THE STORY OF THE NAZI MEDICAL CRIMES. By *Alexander Mitscherlich*, M.D., Head of the German Medical Commission to Military Tribunal No. 1, Nuremberg, and Fred Mielke. Translated by Heinz Norden. With Statements by Three American Authorities Identified with the Nuremberg Medical Trial: Andrew C. Ivy, M.D., Vice-President, University of Illinois, Medical Scientific Consultant to the Prosecution, Military Tribunal No. 1, Nuremberg; Telford Taylor, Brigadier General, U. S. Army, Chief of Counsel for War Crimes; Leo Alexander, M.D., Psychiatrist, Consultant to the Secretary of War and to the Chief of Counsel for War Crimes, and a Note on Medical Ethics by Albert Deutsch (Including the New Hippocratic Oath of the World Medical Association). Cloth. Price, $3.00. Pp. 172, with 24 illustrations. Henry Schuman, Inc., Publishers, 20 E. 70th St., New York 21, 1949.

This is a necessary book, it is must reading for anyone with a serious concern about world affairs. This is a necessary book because without it the atrocities it relates would become unbelievable with the passage of time. Mankind cannot afford to forget the medical crimes of Nazi Germany. Mankind cannot afford to forget the dreadful lesson that science corrupted by venality by racism — can be made to serve the most vicious instincts known to man.

The state hospital of Eglfing was one of the best known state hospitals in Europe. Dr. Hallevorden was the well known neuropathologist, who with Spatz, identified the brain lesions in Hallevorden-Spatz disease. He received the brains of hundreds of murdered patients and gave exact instructions about how their brains should be handled, before these people were killed. This, of course, is clear complicity in murder. This is only one of the points that bring this problem closer home than appears on the surface.

CORNELL CONFERENCES ON THERAPY. Volume III. Edited by *Harry Gold*, M.D., Managing Editor. Cloth. Price, $3.50. Pp. 337. The Macmillan Company, 60 Fifth Ave., New York 11, 1948.

This publication should be a very valuable medium for postgraduate education particularly for the general practitioner. The conference method of discussion brings out many practical details of therapy often omitted in more formal presentations. The treatment of nine conditions is discussed and there are special discussions of streptomycin, protein hydrolysates and BAL. The chapters of most interest to the physiatrist are those on the management of pain due to muscle spasm and the treatment of thrombophlebitis. The addition of a few selected references would add to the usefulness of the book, particularly in relation to some of the newer pharmaceutical agents.

RECENT ADVANCES IN THE STUDY OF VENEREAL DISEASES: A Symposium. Held under the auspices of the Syphilis Study Section, Division of Research Grants and Fellowships, National Institute of Health, U. S. Public Health Service in the Auditorium of the U. S. Department of Commerce, Washington, D. C., April 8-9, 1948. Chairman, Syphilis Study Section: *J. E. Moore*. Price, $1.50. Pp. 341, with illustrations. Published in cooperation with the United States Public Health Service. Venereal Disease Education Institute, 216 North Dawson St., Raleigh, N. C., 1948.

Venereal diseases have contributed a major public health problem in the United States for a generation and the United States Public Health Service through its own efforts and those of many clinicians, educators and investigators has made significant advances in combating their ravages. The symposium presented in this volume represents achievements made possible by research grants to outstanding investigators. The contents

are classified under: Experimental Syphilis, Serologic Tests for Syphilis, Early Syphilis, Jarisch-Herxheimer Reaction, Gonorrhea, Neurosyphilis, Primary Optic Atrophy, Miscellaneous Manifestations of Syphilis, Other Venereal Diseases, Pharmacology and Experimental Therapeutics. All physicians will benefit by the knowledge of the results of these investigations and they are also of vital interest to every worker in this large field in order to keep fully informed about the recent progress made.

EVERYDAY PSYCHIATRY. CONCISE. CLINICAL. PRACTICAL. By *John D. Campbell,* M.D. Diplomate, American Board Neurology and Psychiatry, Psychiatrist to St. Joseph's Infirmary and Crawford W. Long Hospital, Atlanta, Ga.; Instructor in Psychiatry, Emory University Medical School; Captain, M.C., U.S.N.R. Second Edition. Cloth. Price, $6.00. Pp. 394. J. B. Lippincott Company, 227 S. 6th Street, Philadelphia 5, 1949.

The first edition of this volume was written four years ago to bridge the gap between medicine and psychiatry and it was well received. Much of the original material of the book pertained to military problems. In the new edition emphasis is placed upon the psychiatric problems of civilian practice, the evaluation of the nervous maladjusted patient through symptom diagnosis and the institution of effective office treatment. The author discusses in detail the four personality traits, intelligence, conscience, emotional reaction and psychosexual development, as well as the two secondary personality factors, sociability and special modes of adjustment. Two entirely new chapters have been added on involutional syndromes and involutional melancholia and dynamic and environmental factors. This should be a useful guide for general practitioners who come in daily contact with minor mental aberrations and psychosomatic problems.

PERSPECTIVES IN MEDICINE. SIX LECTURES TO THE LAITY ON FRONTIERS OF MEDICAL RESEARCH. THE MARCH OF MEDICINE, 1948. Number XIII of The New York Academy of Medicine Lectures to the Laity. Fabrikoid. Price, $2.50. Pp. 163. Columbia University Press, 2960 Broadway, New York 27, 1949.

Six eminent authorities discuss research and progress upon six of the most vitally important frontiers of medical research. These lectures are: "The Atom in Civil Life," by Lewis B. Strauss, Member of the U. S. Atomic Energy Commission and of the Naval Research Advisory Board; "Food and Civilization," by Sir Raphael Cilento, M.D., Director, Social Division, United Nations; "On Being Old Too Young," by Edward J. Stieglitz, M.D., Chief of Medical Staff, Suburban Hospital, Washington, D. C.; "Perspective in Cancer Research," by Cornelius P. Rhoads, M.D., Director, Memorial Hospital, New York; "Psychiatry for Everyday Needs," by William B. Menninger, M.D., The Menninger Foundation, Topeka, Kansas; "The Interrelation of Pure and Applied Science in the Field of Medicine," by James B. Conant, Ph.D., President, Harvard University.

These lectures are an impressive documentation of the ever widening frontiers of medicine and make fascinating reading for laymen and physicians alike.

PSYCHIATRY FOR NURSES. By *Louis J. Karnosh,* B.S., Sc.D., M.D., Clinical Professor of Nervous Diseases, School of Medicine, Western Reserve University; Director of Neuropsychiatry, Cleveland Clinic. With the collaboration of Dorothy Mereness, A.B., M.N., R.N. Formerly instructor of Psychiatric Nursing, Neuropsychiatric Division, City Hospotal, Cleveland. Third Edition. Fabrikoid. Pp. 437, with 39 illustrations. Price, $4.00. The C. V. Mosby Company, 3207 Washington Blvd., St. Louis 3, 1949.

In view of the accepted importance of an understanding of psychiatry in medical practice, it is necessary that nurses and physical and occupational therapists as well as physicians and surgeons have proper background knowledge of the specialty. This text is well suited for use in nursing schools and also for physical and occupational therapists if additional technical information is provided for the latter.

The present edition adds recent developments in psychiatric treatment in relation to war neuroses and in particular shock therapies and psychosurgery.

The book is recommended as very adequate for instruction of nurses, and with minor limitations for student physical and occupational therapists.

CURRENT THERAPY — 1949. LATEST APPROVED METHODS OF TREATMENT FOR THE PRACTICING PHYSICIAN. By *Howard F. Conn,* M.D., Editor. Consulting Editors: M. Edward Davis, Vincent J. Derbes, Garfield G. Duncan, Hugh J. Jewett, William J. Kerr, Perrin H. Long, H. Houston Merritt, Paul A. O'Leary, Walter L. Palmer, Hobart A. Reimann, Cyrus C. Sturgis, Robert H. Williams. Fabrikoid. Price, $10.00. Pp. 672. W. B. Saunders Company, West Washington Square, Philadelphia 5, 1949.

This a book designed for the general practitioner. It is divided into fourteen sections so as to include most every disease and disorder of the body. The editor secured a board of twelve consultants, including such outstanding clinicians as Reimann for diseases of the respiratory system, O'Leary for dermatology and syphilology, Duncan for metabolism and nutrition, Sturgis on hematology, Kerr on cardiovascular diseases, etc. This board of consultants selected more than two hundred authorities to write articles on their method of treating the various diseases. For example, in diseases of allergy, fourteen subtitles are covered by thirteen different authors; in the section on obstetric and gynecologic conditions, sixteen authors give their treatment for fourteen disorders; in diseases of the endocrine system, the

therapy of thirteen manifestations are described by fifteen authorities, etc.

The book is confined to therapy alone with no consideration given to diagnostic procedures. It is assumed that the physician has already arrived at the correct diagnosis. The style of the book makes for quick and easy reference with a minimum of superfluous words and phrases.

With the rapid changes that are occurring, a book of this type should supply a busy physician with the latest and most effective means of caring for most of the patients he sees in his practice.

THE VENOUS PULSE AND ITS GRAPHIC RECORDING. By *Franz M. Groedel*, M.D., Attending Cardiologist, Beth David Hospital, New York. Cloth. Price, $5.50. Pp. 223, with 121 illustrations. Brooklyn Medical Press, Inc., Box 99, Station H, New York 25, 1946.

The brilliant observation of Harvey in 1628 described for the first time the circulation of the blood and subsequent studies have since that time clarified the mechanics of the arterial flow, but as Groedel points out, not enough attention was paid to the study of the return venous blood stream and some of its phases are still a matter of discussion. The author shows the modern phlebography technic and reports the interpretations given to the phlebogram by various clinicians. This is done through some 114 phlebograms, each accompanied by a clinical history and findings. Some 20 pages are given to discussion of the pneumocardiogram or respiratory pulse which is one of the disputed auxiliary forces for the back flow of the blood to the heart through pressure changes in the thorax with each heart beat. Finally, the respiratory pressure changes in the esophagus, the esophago-cardiogram is discussed. The author concludes that the phlebograph is one of the most valuable methods for research and is the only clinical method to produce a graphic record of the beginning and ending of nearly every important phase during the cardiac cycle.

TEXTBOOK OF THE RHEUMATIC DISEASES. Edited by *W. S. C. Copeman*, O.B.E., M.D., F.R.C.P. Physician to the Rheumatism Department and Lecturer in the Medical School, West London Hospital; Physician to Arthur Stanley Institute of Rheumatic Diseases (Middlesex Hospital) and Hunterian Professor, R.C.S.; Senior Physician the Hospital of St. John and St. Elizabeth; Consultant for Rheumatic Diseases Royal Hospital for Incurables, and Consultant to L.C.C.; Hon. Medical Secretary Empire Rheumatism Council; Member of Minister of Health's Advisory Subcommittee; Chairman of Chartered Society of Physiotherapy and of the British Branch of Ligue Internationale contre de Rheumatisme; Examiner in Physical Medicine for Royal College of Physicians; Heberden Medallist (1940). Cloth. Price, $12.50. Pp. 612, with 351 illustrations. Williams & Wilkins Company, Mt. Royal and Guilford Aves., Baltimore 2, 1948.

Twenty-four British physicians of much experience and intimate knowledge of the various phases of the rheumatic diseases have produced this book. Each author has written about his special interest, with the result that the opinion of an authority is available for the many aspects of these diseases. The contributions are by several physicians who have written notable books themselves and include Kersley, Fletcher, Watson-Jones, Buckley, the editor, Copeman, and others.

The first 100 pages of the book are concerned with fundamental aspects of joint anatomy and physiology and how they are altered by the rheumatic diseases. There is a chapter on the skin and subcutaneous tissues and its relation to the articular disorders; another on pain and its significance in the pathologic changes that occur not only in the joint but in the structures surrounding the joint, and the last chapter in this group on "Climatic and environmental factors in the rheumatic diseases," which shows how these factors influence the various symptoms in these patients. The changes produced by variations in environmental temperatures are dealt with as they apply to the alterations in blood flow in the superficial and deeper tissues, the muscular activity and its response to cold, acclimatization, etc. In these pages a great deal of information is supplied which will aid in a better understanding of the symptoms and changes that occur in the rheumatic disorders.

The chapter on rheumatoid arthritis is only twenty-two pages long which is relatively short when compared with the 55 pages devoted to gout and the 51 pages to the rarer arthritic syndromes; however, the subject is adequately covered. Dr. Davidson, the author of this chapter, has employed good judgment in omitting most of the controversial material and including only the accepted facts as to etiology, pathology and treatment.

Gout is presented by Henry Cohen and is most complete. It begins with a short history of the disease including the aphorisms of Hipprocrates which are seldom quoted and continues with the usual consideration of the various clinical manifestations, etiology, chemistry of uric acid, treatment, etc. The roentgenograms of the typical changes in gout and those other diseases which are confused with gout are well chosen and are of unusual clarity.

A chapter on "Non-articular rheumatism" deals with the controversial subject of fibrositis, herniated fat pads, and other similar disorders. The impression gained from this chapter is that the enthusiasm for the diagnosis of fibrositis is beginning to wane and since this emanates from England, it is surprising; many rheumatologists would encourage this trend.

A good section is the one on brachial neuralgia which clearly and systematically covers the lesions about the neck and shoulder regions. Complaints for these areas appear to be more prevalent during the past few years and are often confused

with articular diseases so that the editor has wisely included this chapter.

Radiology of the rheumatic diseases is extremely well presented with radiographs that are well chosen and reproduced. The illustrations are sufficiently clear so that the differential features can be seen. The radiologic changes noted in the different stages of rheumatoid and osteoarthritis are excellent.

The two chapters devoted exclusively to physical treatments are not the best. The consideration for the various measures is rather superficial. The omission of specific instructions is not helpful nor is the inclusion of questionable methods.

This is a valuable addition to the ever increasing number of books on the rheumatic diseases and will rank among the best.

MUSCLES: TESTING AND FUNCTION. By *Henry O. Kendall* and *Florence P. Kendall*, Physical Therapy Department, Children's Hospital School, Baltimore, Maryland. With a foreword by George E. Bennett, M.D., Emeritus Adjunct Professor of Orthopedic Surgery, and Robert W. Johnson, M.D., Adjunct Professor of Orthopedic Surgery, Johns Hopkins Medical School, Baltimore, Maryland. Cloth. Price, $7.50. Pp. 278. With 162 illustrations. The Williams & Wilkins Company, Baltimore, 1949.

Theories and systems of procedures in the testing of muscles are presented clearly and graphically in the light of their experience and study.

Four types of charts used in recording muscle examination are used: Diagnostic charts for nerve lesions, cranial nerve chart, poliomyelitis charts and body mechanics chart.

The remainder of the book deals with specific tests.

The appendix contains origins and insertions of muscles grouped according to joint action.

ALLERGY. WHAT IT IS AND WHAT TO DO ABOUT IT. By *Harry Swartz*, M.D., Clinical Assistant, Allergy Out Patient Department, Roosevelt Hospital. Cloth. Pp. 210. Price, $2.75. Rutgers University Press, New Brunswick, 1949.

One in every two persons has an allergy. But most of us have only a superficial, and often entirely incorrect knowledge of what allergy is and how we can deal with it. For example, the form of allergy which we commonly called hay fever is not due to hay, and fever plays no part in it.

Allergy, the author tells us, may be caused by any aspect of our environment: by dusts, pollens, textiles, food, drugs, chemicals, plastics, cosmetics, furs, by emotional agents, insecurities, fears, anxiety and other maladjustments in human relationships. Dr. Swartz has written this book to make the mystery of allergy understandable to the millions affected by it and to tell what they can do about it.

This is an excellent book for the doctor to recommend to his patient who has an allergy.

SCIENCE AT WAR. By *J. G. Crowther* and *R. Whiddington*, C.B.E., F.R.S. Cloth. Pp. 185. Price, $6.00. Philosophical Library, Inc., New York 16, N. Y., 1948.

This volume contains information on radar, operational research and atomic energy. It is most interesting and describes the use of radar and other scientific applications which were in use in World War II.

From a medical standpoint, physiatrists will be interested in the historical development of vacuum tubes and magnetrons and the explanation of how they function.

Regarding diagnosis and therapy, there is very little, if any, in the book but it is fascinating reading on the defense of England by the utilization of scientific development during the war.

TAKE OFF YOUR MASK. By *Ludwig Eidelberg*, M.D. Cloth. Price, $3.25. Pp. 230. International Universities Press, Inc., 227 W. 13th St., New York 11, 1948.

This volume is an interesting attempt to give a popular description of psychoanalytic methods and "treatments." It introduces characters and situations based upon actual case histories and shows what actually goes on in a session when "a repressed wish becomes conscious," how patients' dreams are decoded, their association untangled and patients are taught how to separate the neurotic part of their personality from the normal. The dialogue in such stories as "Leave Me Alone," "Better Than the Love of Women," "My Wife Is Unfaithful," "Her Master's Voice," appears quite real and the basic conception is definitely Freudian all the way through, to say the least.

EMERGENCIES IN MEDICAL PRACTICE. Edited by *C. Allan Birch*, M.D., F.R.C.P., Physician, Chase Farm Hospital, Enfield. Cloth. Price, $7.00. Pp. 468, with 113 illustrations. Williams & Wilkins Co., Mt. Royal and Guilford Aves., Baltimore 2, 1948.

This book defines a medical emergency is any condition or circumstance of a patient which calls for immediate action other than surgery. The author says that when events are moving fast, it is the physician who is deeply versed in the natural history of the disease who is likely to be of the greatest service to the patient in peril of his life. Eyes without the microscope, ears without the stethoscope, wits without the help of chemistry and radiology, not that we should deny ourselves the proper use of these, can often carry us a long way. In an emergency they may have to carry us the whole way. Another important aspect of emergencies which it behooves us to remember is the anxiety of the patient and his relatives. When a physician is summoned he should at once preserve this equanimity. The attitude of the physician should be one of alertness in diagnosis, safety in the treatment and care in what we say. All physicians will be interested in reading this book.

PHYSICAL MEDICINE ABSTRACTS

Present-Day Education in Physical Medicine. William Bierman.

New York State J. Med. **49**: (Apr. 15) 1949.

The term "physical therapist" is now applied to the technician in this field. Formerly it was employed to designate the physician-specialist who is now called a "physiatrist." A review of the curricula required and suggested for the physical therapist, occupational therapist and the physical education therapist shows that all three must spend a considerable percentage of their time in learning the same subjects, such as anatomy, physiology, kinesiology, psychology and hygiene. The possibility of training one individual in all three of these technical branches should be considered. A technician so educated would be better able to comprehend the advisability of applying one technic rather than another in the treatment of a given patient. She also could be of service to smaller institutions unable to afford several technicians. A curriculum covering a period of four years could act as a basic one. A graduate could then specialize further in that division in which she desires to become more proficient. A four-year course such as that indicated, because of its technical nature, may prove attractive to many high school graduates who desire to enter into some phase of medicine and are not attracted to the field of nursing. There are objections to this plan for the training of the physical therapist. It is doubtful whether, in view of the present educational concept of the necessity for the incorporation of so-called "cultural subjects" in courses leading to a degree, any university would issue one to a student who devoted her time to the acquiring of knowledge which would be considered as almost exclusively vocational.

Rehabilitation. Howard A. Rusk.

J. A. M. A. **140**:286 (May 21) 1949.

To the physician the term "rehabilitation" has long connoted "the restoration of the handicapped to the fullest physical, mental, social, vocational and economic usefulness of which they are capable." In general usage, however, the term itself, during the past few years, has lost much of its significance, for it has been used to describe everything from correctional programs in modern penal institutions to the social and economic rebuilding of war devastated countries. With the developing emphasis placed on the processes of restoring handicapped workers, a new term has arisen which describes such processes more aptly and with more virility. That term is "the third phase of medical care." The practice of rehabilitation for any physician begins with the belief in the basic philosophy that the physician's responsibility does not end when the acute illness is ended or surgery is completed; it ends only when the patient is retrained to live and work with what is left. This basic concept of the physician's responsibility can be achieved only if rehabilitation is considered an integral part of medical service. Any program of rehabilitation is only as sound as the basic medical service of which it is a part. The diagnosis and prognosis must be accurate, for it is on them that the feasibility of retraining is determined. In addition to the general diagnostic studies, the medical evaluation of the orthopedically handicapped must include muscle tests, determination of joint range of motion and tests for the inherent needs in daily living. In the rehabilitation service at Bellevue Hospital, a check list of ninety-six items is used to determine these factors. They include bed activities, such as moving from place to place in bed, and the ability to sit erect; toilet activities; eating and drinking; the ability to dress and undress, such as tying shoe laces, manipulating buttons, zippers and other fasteners, and applying and removing braces; hand activities, for example, winding a watch, striking a match and using various door knobs and latches; wheel chair activities, getting from the bed to the wheel chair, the wheel chair to bed, and in and out of the bathtub, and elevation activities, which include the needed abilities for walking, climbing and traveling. Regardless of the type of disability, the responsibility of the physician to his patient cannot end when the acute injury has been cared for. It ends only when the physician has taken the responsibility for seeing that proper referral has been made to those agencies and institutions which are equipped to rehabilitate and retrain the patient with a residual physical disability. The physician who fails to see that those patients under his care receive the full benefits of modern methods of medical rehabilitation and retraining is in the same category as the physician who still persists in using dietary restrictions alone in the management of diabetes, when insulin is available, for medical care is not complete until the patient has been trained to live and work with what he has left.

Testicular Degeneration as Result of Microwave Irradiation. C. J. Imig; J. D. Thomson, and H. M. Hines.

Proc. Soc. Exper. Biol. & Med. **69**:191 (Nov.) 1948.

Imig and his coworkers comment on the fact that lower temperatures exist in the scrotum than in the abdominal cavity and that exposure of the testes to abdominal temperatures results in

disorganization of the germinal epithelium of the seminiferous tubules and impairs spermatogenesis. In this study they are concerned with the effects of 12 cm. electromagnetic waves and of infrared irradiations on the testes of adult albino rats. A single ten minute exposure to microwaves at a temperature of 35 C. as measured in the central areas of the testes caused testicular degeneration in all cases. In some experiments testicular damage resulted from a single exposure at temperatures between 30 and 35 C. Testicular damage was not found in experiments in which infrared irradiation was applied for ten minutes at 38 C but was observed when applied at a temperature of 40 C. and above. The type of degeneration resulting from exposure to microwaves could not be distinguished from that produced by infrared. Thus it has been demonstrated that testicular damage will result from 12 cm. irradiations at a temperature below that of the abdominal cavity and below that necessary to cause injury by exposures to infrared rays. This finding suggests that damage may result in part from factors other than heat. It is suggested that precautions should be taken by those working in the field of high frequency electromagnetic generators and by those giving treatments with microwave generators.

Physical Treatment of Backache. Frederic J. Kottke.

J. A. M. A. 139:1055 (Apr. 16) 1949.

Pain low in the back is a common reason for patients to seek medical aid. There is a larger number of patients in whom the backache is not due to demonstrable bony change.

Treatment of low back pain has a twofold aim: to relieve the pain in the area of initial trauma and to relieve the muscle spasm and its concomitant effects. For the relief of muscle pain, heat is one of the best analgesics. All types of heat are useful to relieve deep pain or muscle spasm. Short wave diathermy is probably in general preference today because of its efficacy and ease of administration. However, it is my experience that woolen hot packs, heated in boiling water, centrifuged nearly dry and then quickly applied, are the most effective method of relieving muscle spasm. These packs feel extremely hot since they are applied at a temperature of about 80 C., but because of their low water content there is too little heat to blister the skin. After the application of heat, massage is used to increase the threshold for pain and to obtain greater relaxation. Massage is begun gently and increased in pressure gradually as the patient's tolerance increases.

Neither heat nor massage is able to stretch muscles out to their full resting length. Therefore, these forms of treatment are followed by passive or active stretching exercises to increase suppleness. Stretching exercises must be vigorous and must be designed to stretch the muscles which have been held in a shortened position. Movement of these muscles through the range from full contraction to complete relaxation prevents the development of connective tissue which would tie the muscle fibers down with fibrous contractures and perhaps lead to a permanent deformity.

Immobilization of an acute muscle strain allows development of fibrosis and prolongs the condition.

All patients with backache should be advised concerning the type of bed to use. The modern bed with a soft innerspring mattress aggravates backaches. It is the observation of many patients with chronic backache that they can sleep better on the floor than in a soft bed. Patients with backache should be advised to sleep on a felt or hair mattress placed on bed boards without a spring. This provides the flatness and support needed to allow the muscles of the back to relax during sleep. Many patients find relief from a chronic backache merely by substituting a firm flat bed for the modern flexible bed.

Physical Treatment Poliomyelitis: Responsibilities of the Physician in General Practice. Robert L. Bennett.

J. A. M. A. 139:1053 (Apr. 16) 1949.

No known method of treatment, chemical or physical, can appreciably alter the patterns of destruction wrought by the invasion of the virus in the central nervous system during the acute stage of the disease.

No magical formula for mixing together heat, massage and exercise has been discovered. The value of physical treatment is completely dependent on the ability of the physician first to evaluate the specific needs of his patients and, on the basis of this knowledge, then outline the individual programs of care. No physician should undertake the care of convalescent poliomyelitis unless he thoroughly appreciates the responsibilities that he must assume and the physical tools with which he must work to fulfil these responsibilities.

All physicians should be able to make a consistently accurate muscle test or, at least, be able to understand thoroughly the results of such a test when done by another physician or therapist. At the present time, no other type of test will give us the practical information as does the manual muscle strength test.

The physician must next be able to obtain effective action of all remaining neuromuscular units, either through his own personal use of physical treatment or through his prescription to the trained therapist.

The physician must next be able to anticipate and correct or minimize the factors responsible for musculoskeletal deformities. It is true that one can do nothing to prevent the weakness and atrophy that must follow actual denervation of muscle fibers, but one can and must prevent the structural changes that develop in bodily segments inadequately supported.

The physician must not only be capable of no-

ting the earliest deviations from normal patterns of motion and weight bearing but must also be capable of correcting or minimizing these faults through functional training and, when necessary, the use of assistive and supportive apparatus, such as corsets, braces and crutches.

Finally, the physician should appreciate the frequent need for, and value of, certain orthopedic surgical procedures during the convalescent stage. Physical medicine must not be thought of as in competition with orthopedic surgery. It is essential that the physician caring for the convalescent phase of this disease foresee the possibilities of later surgical procedures and through his treatment maintain the involved segments in such condition that, if necessary, the surgeon can add to the patient's greater functional capacity and security at the optimum time in the over-all program for maximum rehabilitation.

Physical Treatment of Peripheral Vascular Disease. Sedgwick Mead.

J. A. M. A. 139:1059 (Apr. 16) 1949.

In no other set of conditions is a proper balance between medical, surgical and physical methods of treatment more essential than in diseases of the peripheral circulatory systems. Rational therapy must be based first of all on a thorough understanding of their anatomy and physiology, both normal and morbid; secondly, on accurate methods of evaluation, and, finally, on a thorough knowledge of all methods of treatment and of judgment and discrimination in their application.

It should be emphasized that in the physical treatment of vascular disease good judgment is more important than elaborate equipment. Ingenious improvisations, of which one saw so much during the late war, often serve well. One must avoid placing too much responsibility on the therapist, who, unless provided with a complete, thoughtful and detailed prescription, tends to fall into a routine rut. If the physician is vague about the objective of his treatment and imprecise in ordering its details, he can scarcely hope that the therapist will be any less vague in its execution. If he fails to observe that the patient has loss of pain and temperature perception, he should not blame the therapist for producing a diathermy burn. On the other hand, he cannot personally check every phase of the treatment. His only protection is to insist that the therapist be registered and a graduate of an accredited school.

Physical Medicine and Preventive Medicine. J. Wayne McFarland.

South. M. J. 42:29 (Jan.) 1949.

Physical medicine, the newest specialty of medicine, is in a unique position. It has the opportunity of building upon the broad base of medical and surgical specialties now well established, and at the same time brings to the field of medical research the new and tremendously important basic science, biophysics. Physical medicine has been defined as the employment of physical and other effective properties of light, heat, cold, water, electricity, massage, manipulation, exercise, and mechanical devices in physical and occupational therapy for the purpose of diagnosis and treatment of disease. Rehabilitation is the newest phase added to the ever-expanding specialty of physical medicine.

Physical measures have a most definite place in the prevention of disease. The definition of physical medicine should more correctly read: physical medicine may be defined as the employment of physical and other effective properties of light, heat, cold water, electricity, massage, manipulation, exercise and mechanical devices in physical and occupational therapy for the purpose of prevention, diagnosis and treatment of disease.

Physical Treatment of Common Disorders of the Feet. Frances Baker.

J. A. M. A. 139:1057 (Apr. 16) 1949.

The author has presented a discussion of treatment of the common disorders of the feet. The primary causes for most obvious distortions are: A failure of full evolutionary development which is evidenced by variations of the first metatarsal segment or of a metatarsus varus. Muscular contractures of hamstrings, calf muscles or the plantar muscles and fascias which result in pes equinus or pes cavus. Hyperflexibility of ligaments which results in pes valgus. Such congenital or developmental anomalies as pes equino varus, accessory scaphoid bones, calcaneonavicular coalitions and epiphysitis which can cause strain and variations from the normal alinement. Pathologic conditions which cause paralyses or arthritis and present themselves here as in other parts of the body.

Causation and Treatment of Painful Stiff Shoulder: Subdeltoid Bursitis, Periarthritis, Tendinitis and Adhesive Capsulitis. H. W. Meyerding, and J. C. Ivins.

Arch. Surg. 56:693 (June) 1948.

Meyerding and Ivins present clinical observations on 150 consecutive cases of stiff painful shoulder, in which manipulation with patient under anesthesia, surgical excision of calcified plaques or bursas, injection or needling was performed at the Mayo Clinic during the years 1942 through 1946. The duration of symptoms varied, but in 65 it was of less than a year. Roentgenographic examination revealed calcification in 59 cases and osteoporosis in 34. Since the evidence of calcification depends on the degree of deposit, calcification doubtless was present in more cases. Pain, stiffness and local tenderness were the characteristic symptoms, and they often followed some exertion, such as gardening, painting and washing walls. The pain usually was intermittent. The patient with the acute stage of the disease or with intense pain, local tenderness, slight fever and the arm maintained at the side for protection may be treated for a few days by rest in bed, local application of heat, increased intake of fluid, maintenance of elimination and traction, together with

administration of anodynes. Abduction should be encouraged, and conventional diathermy and roentgen therapy may be included, after which patients often are relieved. The authors discuss the treatment to be employed in the subacute and recurrent attacks. In 69 of the 150 cases manipulation with the patient under anesthesia was performed; in 32 additional cases manipulation with injections of procaine hydrochloride into the suprascapular nerve was used; in 31 a needling operation was performed, to pierce and break up the calcareous deposits, and in 18 surgical excisions of the calcareous masses was performed. Forty of the 150 patients received roentgen therapy in addition to other treatment, some of them prior to admission at the clinic. Acute lesions have proved more amenable to roentgen treatment than the more chronic lesions. The authors present detailed reports of 9 patients to illustrate certain points in diagnosis and treatment.

War Injuries of Peripheral Nerves. H. J. Seddon.

Brit. J. Surg. **143**:325 (Jan.) 1949.

Preoccupation with the operative repair of damaged nerves has sometimes resulted in neglect of the nonoperative treatment. Yet even if operation were invariably required, and this is by no means so, satisfactory restoration of function would still depend very largely on the physical treatment of the affected part. As was forcibly pointed out by Ritchie Russell and Harrington (1944), the maintenance of mobility is imperative. There are two chief causes of stiffness — edema and muscle shortening

At each of the nerve injury centers provision was made for the rehabilitation of soldiers and airmen suffering from nerve injuries, and all sorts of occupations were introduced in the endeavor to obtain the best possible functional results. Carpentry, leatherwork, weaving, clay modeling, and sign writing proved of great value, and in many cases the results were such that patients were able to return to duty in a high medical category. The finer grades of muscle coordination and sensory discrimination were not regained after nerve injuries requiring operative repair, though even in these cases return to duty was often possible.

New Method in Management of Acute Anterior Poliomyelitis. E. Smith; D. J. Graubard; N. Goldstein, and W. Bikoff.

New York J. Med. **48**:2543 (Dec. 1) 1948.

Smith and his associates regard the alleviation of pain and spasm as one of the major problems in the management of acute poliomyelitis. They believe that vasospasm is a defense mechanism of tissue response. When an irritable focus is established in the periphery, the organism reacts by vasospasm and exudate. These usually subside at the time healing is complete. However, if an irritative focus persists, a reflex arc producing pain and spasm is established. This arc may perpetuate itself through the internuncial pool and eventually involve the sympathetic motor neuron cells in the lateral horn. Interruption of the cycle of reflexes is, therefore, the method of choice. The results achieved in cases of trauma with the intravenous administration of procaine hydrochloride have indicated that the symptom complex of pain may be controlled in this way. The treatment described was used in 79 of 159 patients with poliomyelitis. Four patients were treated by the intravenous administration of procaine hydrochloride; 73 were treated with priscol hydrochloride (2-benzyl-4, 5 imidazoline hydrochloride) and 2 with diethylaminoethanol. Acute pain was relieved in all cases within twenty minutes to eight hours, procaine hydrochloride giving the quickest and diethylaminoethanol the slowest response. Increasing relief of pain was obtained with succeeding administration to the point of complete relief, at which time the patients were discharged or transferred to orthopedic institutions.

Hydrotherapy and Crenology in Treatment of Sciatica. J. Wery.

Abs. Excerp. Med. (Neurol. and Psychiat.) **2**: 140 (Feb.) 1949.

During the acute period, rest in bed is the most effective treatment. During convalescence hydrotherapy is useful, first in the form of tepid tub baths, then progressing to drip douche, underwater douche, tepid shower baths at increasing temperatures, at first without pressure and then with light percussion; next light massage under the shower, then gentle kneading and finally the massage douche with terminal jet. In funiculities the Scotch (transition) douche often gives good results. In many spas fangotherapy is used (vegetable, vegeto-mineral or marine muds) which provokes distinct vasomotor reactions. Sometimes vapor baths are associated. Hydrotherapy promotes blood supply to the tissues and raises the pH. This is the critical feature of the cure, as excessive alkalosis endangers the results by slowing down capillary circulation. Hyrotherapy is of great value, but only under expert supervision.

The Application of Ultrasonic Waves to the Study of Electrolytic Solutions: II. The Detection of the Debye Effect. Ernest Yeager; John Bugosh; Frank Hovorka, and John McCarthy.

Chem. Physics **17**:411 (Apr.) 1949.

The existence of the alternating potentials which Debye predicted should accompany the passage of ultrasonic waves through an electrolytic solution has been established experimentally by means of a stationary acoustical field. The effect has been shown to depend on velocity variations within the ultrasonic waves, to be a function of the electrolyte and to be independent of concentration for practical purposes in the range of 0.0005 molar for uni-univalent electrolytes. These characteristics are in agreement with theoretical considerations.

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Name of Hospital	Location	Chief of Service	Patients Treated	Number of Treatments	Asst. Res. and Residencies Offered[a]	Beginning of Service (1948)	Length of Service Offered (Years)	Beginning Stipend (Month)
United States Army								
†Letterman General Hospital★	San Francisco	A. V. Bateman	5,994	285,400	2	1/1	1–3	m
†Fitzsimons General Hospital★	Denver	J. H. Kuitert	2,606	119,005	2	1/1	1–3	m
Walter Reed General Hospital★	Washington, D. C.	E. M. Smith	5,573	238,036	3	1/1	1–3	m
†Percy Jones General Hospital★	Battle Creek, Mich.	A. E. White	28,849	346,505	2	.....	1–3	m
Veterans Administration								
Veterans Admin. Hospital	Chamblee, Ga.	W. Steiner	.....	20,400	1	7/1	1+	$275.00
†Veterans Admin. Hospital	Hines, Ill.	L. Newman	37,369	482,980	7	.....	1–3	275.00
Veterans Admin. Hospital	Framingham, Mass.	F. Friedland	10,130	194,794	2	7/1	1–3	275.00
†Veterans Admin. Hospital	Jefferson Barracks, Mo.	F. Ewerhardt	2,589	71,974	2	7/1	1+	275.00
†Veterans Admin. Hospital	New York City	H. Kessler	21,729	247,884	3	1/1, 7/1	1–3	275.00
†Veterans Admin. Hospital	Portland, Ore.	E. W. Fowlks	3,230	85,750	1	7/1	1–3	275.00
Nonfederal								
†Los Angeles County Hospital★[1]	Los Angeles	O. Huddleston	.....	14,633	2	Varies	2	.....
†White Memorial Hospital★	Los Angeles	F. B. Moor	500b	20,000b	1	7/1	1–3	147.33
Stanford University Hospital★[1]	San Francisco	W. H. Northway	.....	6,561	2	7/1	1–2	50.00
†University of California Hospital★†	San Francisco	F. Baker	.....	7,123b	1	7/1	1	50.00
University Colorado Medical Center								
†Colorado General Hospital★[1]	Denver	H. Dinken	2,905	64,050	1	Varies	1–3	75.00
†Emory University Hospital★	Emory Univ., Ga.	R. L. Bennett	7,836	.....	1	.....	1–3	.....
†Georgia Warm Springs Foundation	Warm Springs, Ga.	R. L. Bennett	.....	84,000	1	.....	1–3	.....
Michael Reese Hospital★[1]	Chicago	C. O. Molander	1,534	16,282	2	7/1	1	25.00
Passavant Memorial Hospital★[1]	Chicago	J. S. Coulter	7,784b	12,696b	2A	.....	1	.....
University of Kansas Hospital★	Kansas City, Kan.	Donald L. Rose	2,775	25,347	3	.....	1½	.....
†Massachusetts General Hospital★	Boston	A. L. Watkins	1,639b	16,265b	2	.....	1–3	41.67
†University Hospital★[1]	Minneapolis	M. Knapp	7,677	12,141	2	7/1	1–3	116.00
Mayo Foundation	Rochester, Minn.	F. H. Krusen	.....	**	6	.....	3	.....
†Bellevue Hospital, Div. III—N. Y. Univ.★	New York City	H. A. Rusk	.....	.....	7	Varies	1	70.00
†Goldwater Memorial Hospital★[1]	New York City	H. Behrend	872	53,738	1	.....	1	120.00
†Hospital for Joint Diseases★[1]	New York City	J. Weiss	78,386	91,746	2	1/1	1+	40.00
†Montifiore Hospital for Chronic Diseases★	New York City	K. Harpuder	.....	.....	1	.....	1+	50.00
†Mount Sinai Hospital★[1]	New York City	.....	7,310	9,920	1	1/1, 7/1	1	50.00
†Presbyterian Hospital★[1]	New York City	W. B. Snow	77,771	221,144	1	.....	1	41.66
St. Luke's Hospital★	New York City	R. Muller	2,123	104,604	1	Varies	1	50.00
†Cleveland Clinic Foundation Hospital	Cleveland	W. J. Zeiter	16,257	39,919	1	7/1	1–3	100.00
†Hospital of the Univ. of Pennsylvania★[1]	Philadelphia	G. M. Piersol	1,078	13,883	1	Varies	1	.....
†Medical College of Virginia, Hosp. Div.★	Richmond, Va.	.....	2,953	33,612	1	.....	1	46.80
†State of Wisconsin General Hospital★[1]	Madison, Wis.	H. D. Bouman	3,050	38,382	2	7/1	3	25.00

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The dagger (†) represents temporary approval, *pending formal inspection*, in accordance with the plan for the temporary approval of residencies in specialties as announced in THE JOURNAL, A. M. A., March 2, 1946, p. 586.

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*** Rep. in part J. A. M. A. 137:71 (May) 1948.

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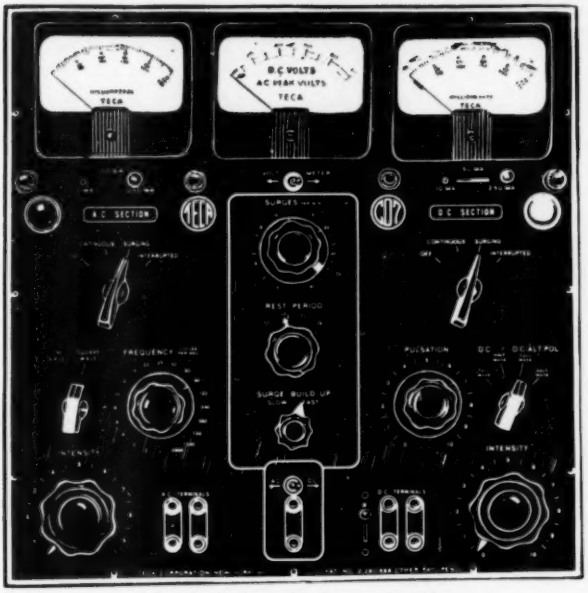

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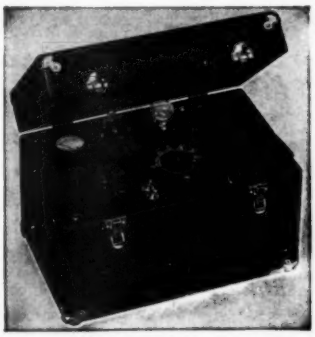

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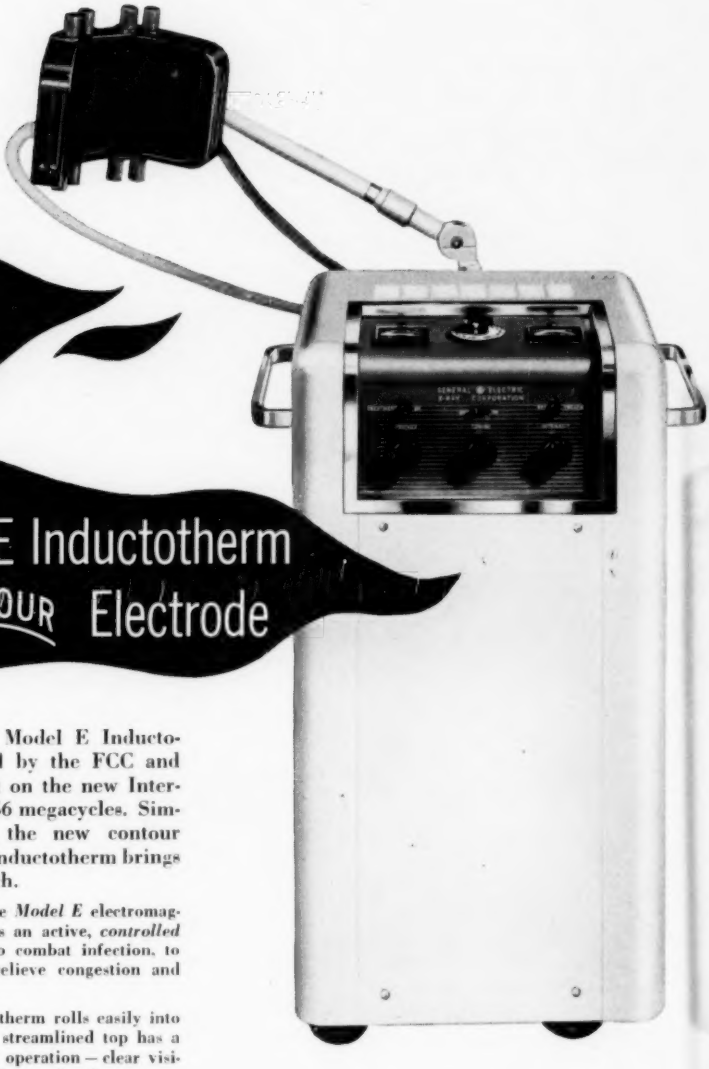

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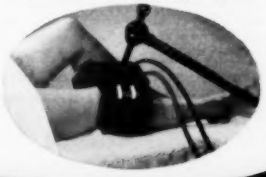

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